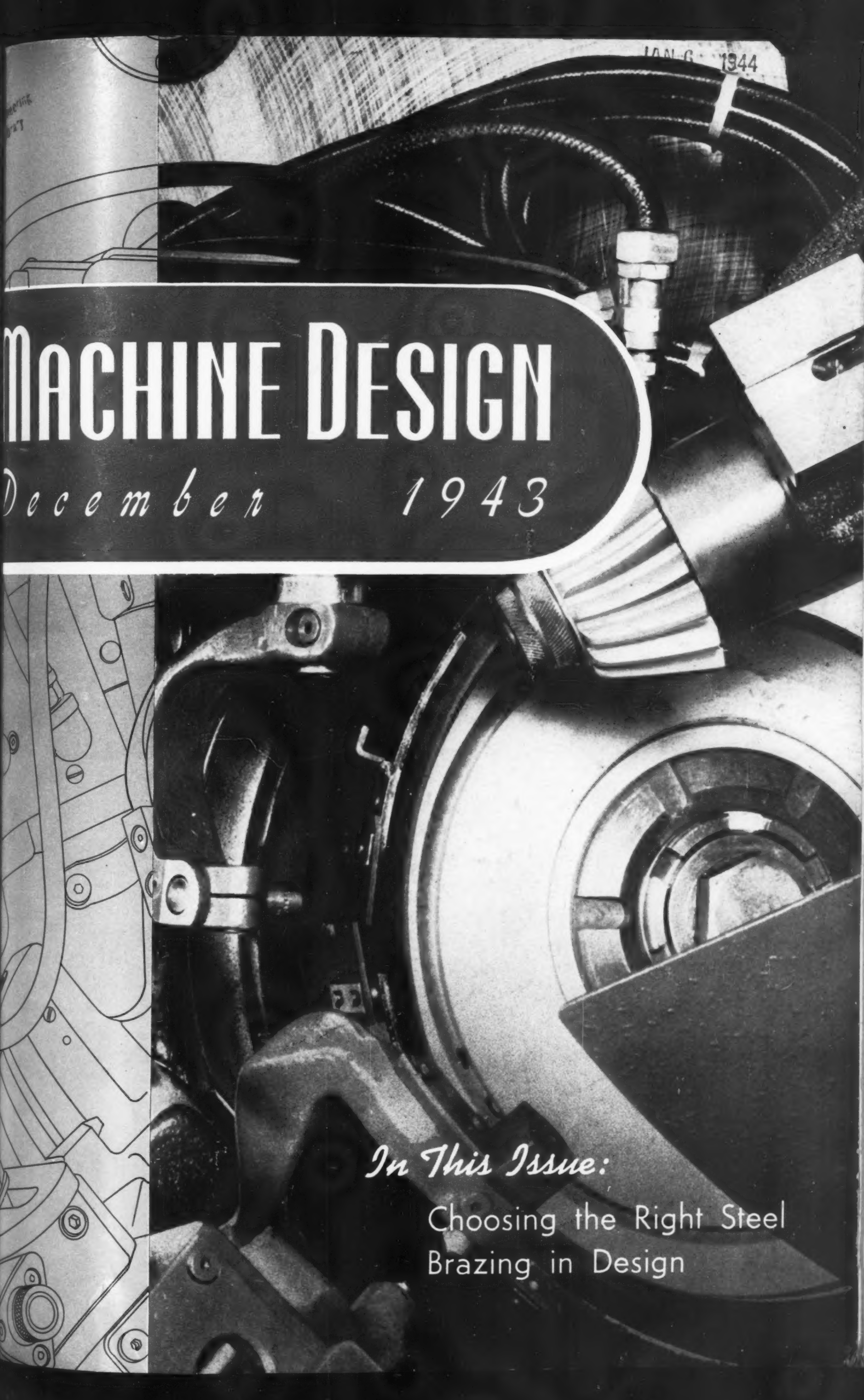
MACHINE DESIGN

December 1943



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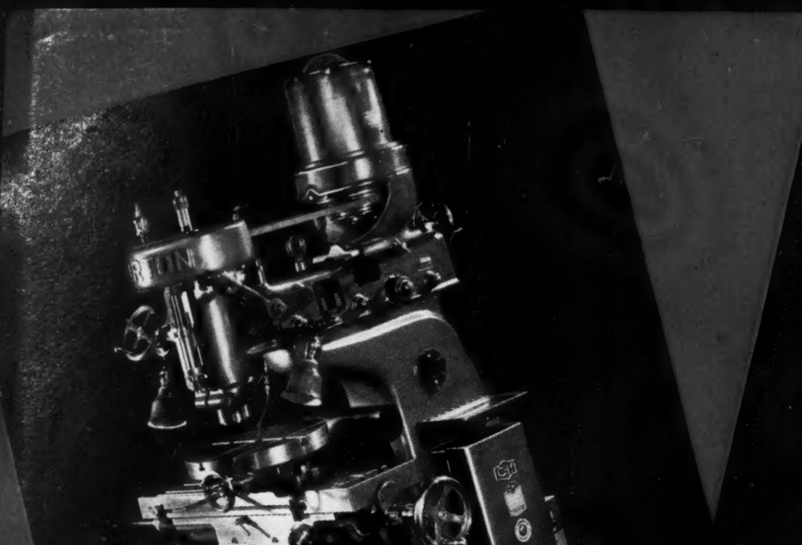

Outstanding example of redesign ... the George Gorton Machine Company's 8½-D Vertical Milling Machine. Photograph at left shows machine *before* redesign, photograph at right *after* redesign. Among many improvements, note how UNITROL has moved control elements inside the machine base, clearing bulky, protruding units away, grouping various operating controls for greater convenience. Weight, bulk and material are saved. Controls for four motors are mounted on UNITROL frame, "door" pierced for fully accessible control buttons.

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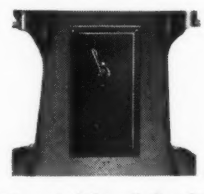
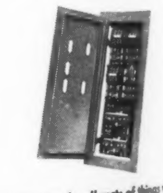
Milwaukee Plants

UNITROL is primarily a means of mounting skeleton starters. Here is shown the basic UNITROL mounting frame, which simplifies machine design and construction.

Here a skeleton starter is mounted in place in UNITROL frame. Door may be left with dead front or pierced for pushbuttons, on-off switch, etc.



Built-in control through the simple expedient of UNITROL. A cavity is cut in base of machine, four screw-holes tapped and UNITROL is simply screwed into place.



You can do all sorts of things with UNITROL. Here control elements are mounted in one frame, door pierced for front pushbutton operation; the entire unit is ready for quick, easy installation.

CUTLER-HAMMER

UNITROL

C-H

MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

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Topics

ANTIFRICTION BEARINGS, ten feet in diameter with races machined and ground to precision limits of .002-inch in diameter and .001-inch in parallelism, are being built for the 5-inch 38-caliber twin antiaircraft gun mount for the Navy by the Bantam Bearings Division of the Torrington Co. One race is 1⅞-inch wide by ¾-inch in cross section and another 1¼-inch wide by 2½-inch in cross section. Variation of 2 degrees Fahr. between gage and race would result in a variation of .0016-inch, necessitating special precautions in manufacturing.

NEW AIRPLANE PROPELLERS with metal core and fairing of hard sponge rubber covered with a shell of rubber and neoprene, polished and lacquered, are much lighter than other types and are able to withstand stresses of 60 tons in flight. Surface is said to withstand rain and sleet as well as cinders, sand and gravel in temperatures ranging between minus 70 to 140 degrees Fahr.

WHERE a high degree of gas tightness is required of castings, polyvinyl chloride and polystyrene "impregnated" in the cores of the castings have shown promise over previous methods of employing lacquer coatings.

ENERGY EQUIVALENT of 50½-million foot pounds is produced by a machine for testing airplane tires, wheels and brakes. Powered by a 150-horsepower motor the machine reaches top speed in 17½ minutes. The main testing wheel weighs about 17,000 pounds. Addition of side plates increase the weight to a maximum of 75,000 pounds. Landing speeds up to 200 miles an hour can be tested.

THIN VINYLITE SHEETING preserves surfaces of prints, instruction sheets, etc., where usage might affect legibility. Special-backed sheeting has been developed for application with a hot iron after which the backing is stripped, leaving a permanently bonded surface.

SIMPLIFICATION and standardization have effected worthwhile economies in the war program. Typical are: Simplification of portable electric tools has reduced size and models by 25 per cent. Standardization of electrical indicating instruments makes possible interchangeability in combat vehicles through reduction in variety of sizes from over 90,000 to 2100. Simplification of incandescent and fluorescent lamps reduced types from 3500 to 1700, colors from 13 to 3 and voltages from 32 to 7—saving 3500 pounds of solder, 2000 pounds of tungsten and 1,200,000 man-hours per year.

STEEL SHRINKAGE is being studied by General Electric so that metallurgists can learn exactly what effects to expect in heat-treating processes. Steel parts when passed through an electrically heated hydrogen furnace as many as 200 times, shrink considerably but do not lose weight.

PLASTIC LAND MINES were used by the Germans almost exclusively on the beaches of Salerno. Made of plastic and concrete to escape detection by electronic devices, these mines also were employed to some extent in North Africa.

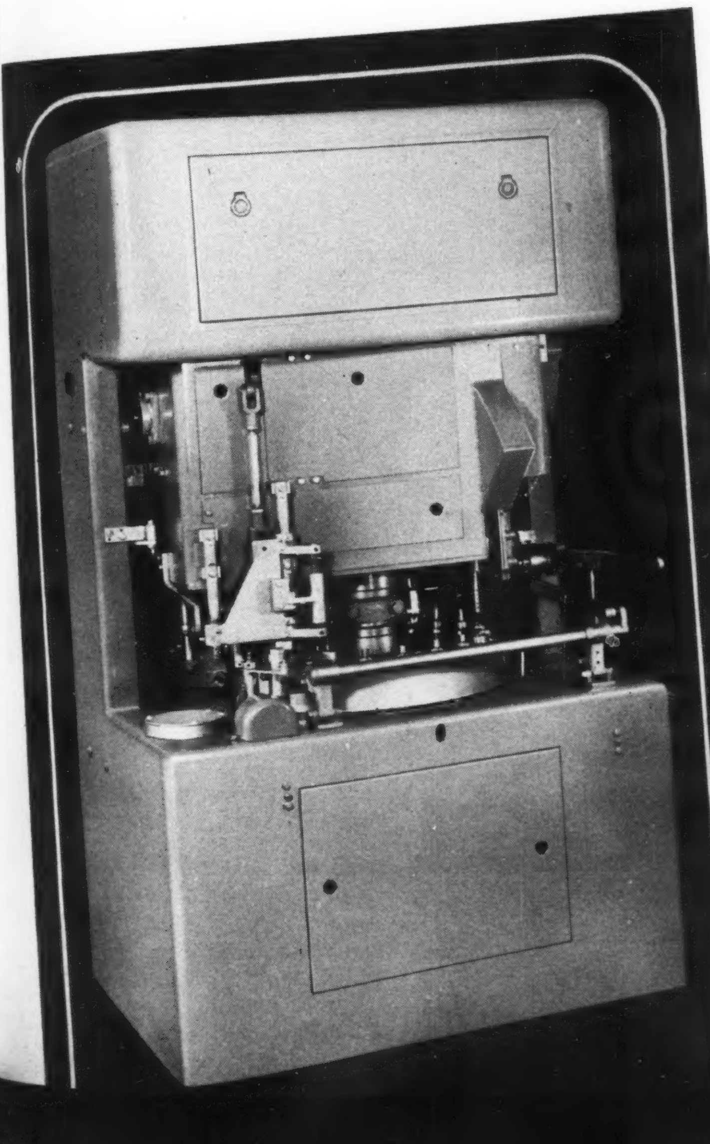
YELLOW is the most conspicuous and visible of hues with brilliant yellow-green, orange and red following in order. Applying these relations, the Color Research Laboratory of the Eagle Printing Co. suggests the use of yellow for moving parts, trucks and the like. Yellow-green and orange could be used for lesser hazards with red reserved for fire-fighting equipment.

SHOT PEENING as a cold working process for increasing the fatigue life of ferrous metals is being studied by an SAE standards committee for the purpose of standardizing the shot, methods of application, and tests and measurements of results.

FOR HOLDING a series of flush rivets in place until the riveting operation is performed, a gummed glassine tape has been used successfully. After fabrication, the tape may be removed without leaving adhesive on the parts.

Designing Automatic Machine for Ordnance Parts

By Royal T. Moore
Consolidated Packaging Machinery Corp.



ASSEMBLING of ordnance components has afforded excellent opportunities for creative skill in the design of automatic machinery, an outstanding example being the primer tube assembling machine illustrated in *Fig.* 1. Many of the problems confronting the designer in developing this machine will undoubtedly be of interest to designers of other types of automatic machines. As an aid to better understanding of these problems, the assembling operations performed on the primer tube will first be reviewed briefly.

A primer tube consists of a tube containing a measured charge of loose powder and a cap containing the firing element. The cap must be fitted tightly to the tube, sealed and locked against movement. In assembling, the cap is partially threaded into the tube. The threads are coated with a sealing mate-

Fig. 1—Although Consolidated primer tube assembler is a special-purpose war production machine, "cleanlining" has been carefully considered in design

rial after which the seating of the cap is completed. It is then locked in position by indenting the walls of the tube against the threads, commonly called staking.

Before applying the cap the level of the powder is inspected to insure that the correct amount has been deposited in the tube. After the cap has been applied to the tube it must be checked as to its proper position before it is finally locked. The height of the tube must also be checked since this must be maintained at a fixed dimension with respect to the operating stations.

In view of the careful attention required throughout the assembling operation it was formerly carried out manually. This was a slow laborious op-

DEVELOPED to perform a series of specific operations on an ordnance component, the machine discussed in this article combines the functions of a skilled manual worker with the watchful eye of an inspector. Though a special machine, it has been designed with the exacting thoroughness of standard equipment

eration requiring an elaborate set of tools. Furthermore, the operation was subject to weaknesses of the human element.

In the development of the machine, the problem confronting the designer was not merely a matter of converting manual motions into mechanical movements. It also involved the embodiment of the watchful eye and sensitive manipulations of a skilled operator. Safety was another factor in view of the handling of explosives. There was also a matter of appearance from a sales viewpoint. Thus, while the machine was a special project it nevertheless was designed with the exacting thoroughness of a standard machine.

General characteristics of the machine are shown in *Fig.* 1, and in the front elevation, *Fig.* 2. A major problem was to determine the most suitable style of machine for this operation and for the conditions under which the machine was to be used. In view of this all types of machines performing similar operations were carefully reviewed.

The continuous motion machine was adopted. In this type the operating

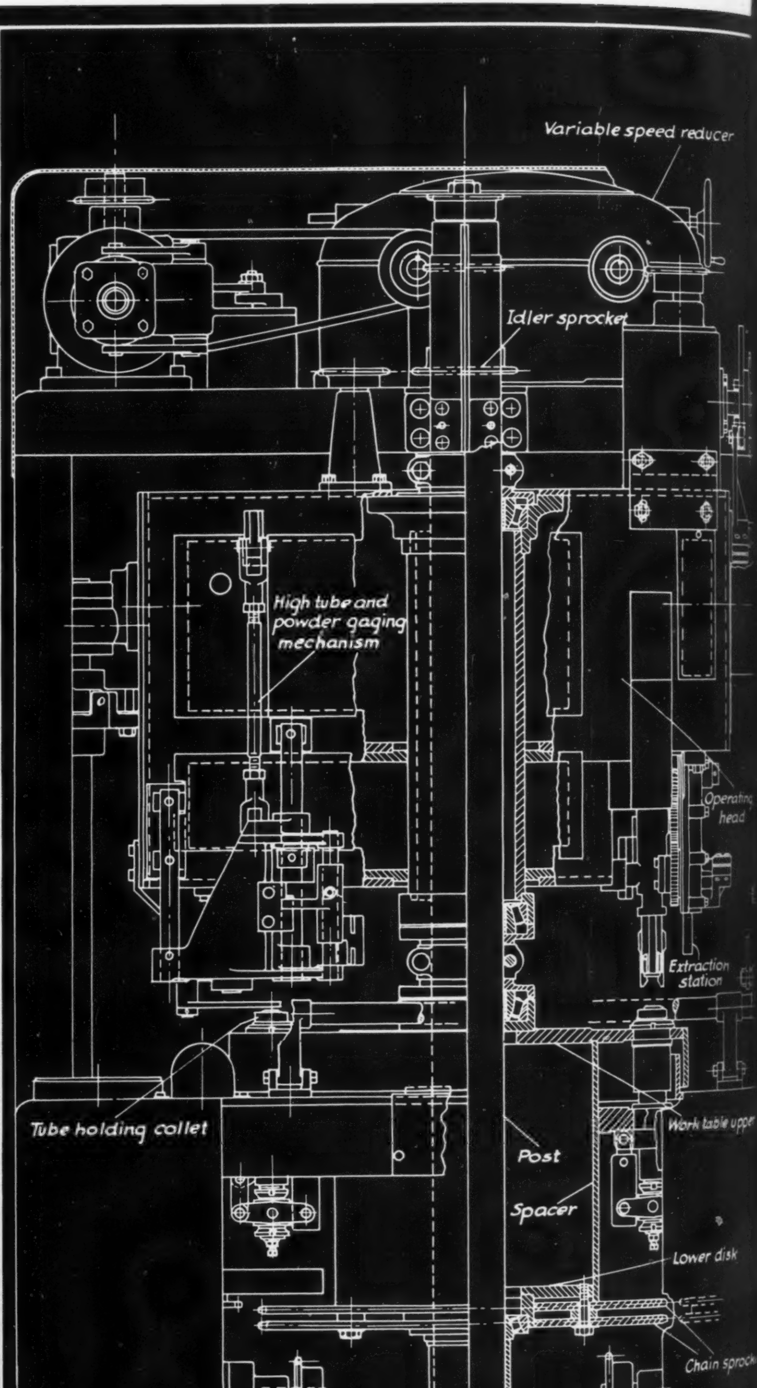


Fig. 2—Front elevation in part section shows principal working parts of the machine, including rotating work table, operating-station head and main drive from variable-speed reducer

stations travel with the work while performing their function. This produces a smoother action, particularly as it relates to the work. It simplifies the design of the machine and obviates the necessity of compensating for vibrations which result from the starting and stopping of intermittent machines.

Machine comprises three major elements, the rotating work table, the operating-station head and the main drive, Fig. 2. Each is more or less a self-contained unit conveniently arranged for adjustments or repairs independently of the other units.

Frame is an all-welded steel structure comprising a box-like base and channel-shape side columns. The tops of the columns are rigidly braced by a cast iron bracket which also functions as a base for the motor and speed reducers. The base is provided with a plate steel floor welded in place.

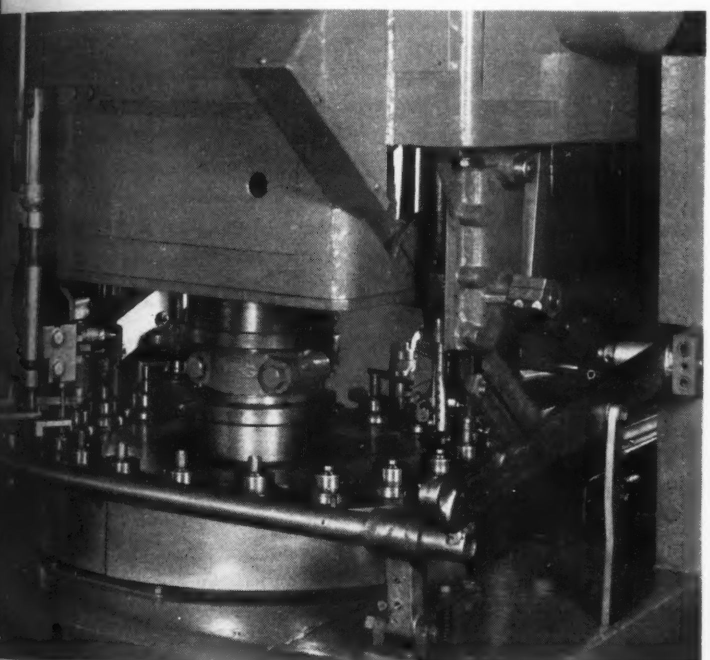


Fig. 3—Close-up view of operating stations shows work-holding collets, tube height detectors at left and extraction station at right

Welded frame construction offers a number of advantages. It provides lasting rigidity, since there are no bolts and nuts to loosen. It simplifies construction by reducing machining and assembling time. Furthermore, it functions as a guard, thereby practically eliminating the necessity of additional guards. It also carries out the trend in streamlining. Doors can be conveniently arranged for attention to enclosed mechanism without weakening the frame or disturbing the effect of streamlining.

Extending centrally upward from the base floor to the overhead bracket is a heavy stationary shaft or post. This member is properly aligned and then secured in place. It constitutes the precision machined member of the frame, and supports the operative elements of the machine. Consequently, any irregularities of the welded fabrication are not transmitted to the mechanism. Here again is evidence of simplification by reducing machining and assembling operations.

Work table is an assembled member consisting of an upper and lower disk spaced apart by a cylindrical shell, *Fig. 2*. Suitably fitted to the lower disk is a heavy duty radial-thrust roller bearing. This bearing is supported by a sleeve mounted on the stationary shaft and seated on the shaft retaining flange. The upper disk is counterbored to receive a similar bearing.

Table is rotated at a speed of two to three revolutions per minute by a two-strand roller chain meshing with a double sprocket secured to the lower disk. The chain is driven from a speed reducer which in turn is driven from another speed reducer located on the opposite side of the base. The latter is driven by a vertical shaft extending down from the main drive overhead.

Work-holding collets or chucks are equally spaced around the outer edge of the table as shown in *Fig. 3*. The opening and closing mechanism extends below the upper surface of the table, but is fully exposed for adjusting purposes. A collet is opened by a cam-actuated system of levers, *Fig. 2*, and closed by a compression spring. This, of course, occurs at timed periods of operation. Since the top of the primer tube must be maintained at a specified dimension from the surface of the table an adjusting means is provided to raise or lower the tube. This consists of spacers within the collet body and a screw threaded into the body and bearing against the spacers. The spacers provide the adjustment required in changing from one tube size to another while the screw furnishes the fine adjustment necessary in setting-up.

Operating Head Is Unique

The operating-station head, which is unique in design and performance, is a machine in itself, mounted for precision oscillatory movement. It contains operative stations which carry out their functions during the movement of the head. In designing this member the first thought concerned the frame. Again the all-welded construction was adopted. As indicated in *Figs.* 1 and 2, the frame is substantially a box with front and rear faces provided with suitable openings. The top and bottom faces are joined by a cylindrical wall. Radial-thrust roller bearings are suitably mounted to the upper and lower end of the cylindrical wall. The lower bearing seats against a split-set collar rigidly clamped to the stationary shaft. A similar set collar is mounted above the upper roller bearing. Thus the head is freely supported in vertical alignment and provided with suitable thrust bearings in either direction.

Head is oscillated by a lever secured to a vertical shaft located on the left-hand side of the machine. The shaft is rocked by a slotted plate cam, operating within the base. The lever is provided with an adjustable feature whereby slight changes in relationship between the head and the cam can be made. The cam is designed to cause the head to oscillate through a number of degrees greater than would be required for the exact spacing of

the work-holding collets. This was done to bring about a smooth change in direction. In a cycle of operations a starting point is selected. At this point the head is swinging forward. At the completion of operations the head continues for a few degrees. The direction is then changed and the head returns for the next cycle. In doing this it passes a few degrees beyond the starting point and then returns to the starting point. In this manner the machine can be accurately timed.

Mechanisms Within the Head

Within the head are the mechanisms for inserting or partially threading the cap to the tube; the cap-tightening device for completion of the inserting operation; the staking element; and the discharge station where the completed primer tube is withdrawn from the collet and deposited on the discharge conveyer. While full descriptions of these various mechanisms are not given it will be understood that the motions involve rotation and raising and lowering.

A main camshaft extending through the frame of the head is driven by a roller chain from a speed reducer mounted on the top of the frame and consequently movable with the frame. The speed reducer is driven by a roller chain from an idler supported by the stationary shaft. Revolving elements are driven by a roller chain from an idler sprocket secured to the same shaft as the reducer idler.

Main drive of the machine is designed for either individual motor or lineshaft operation. The source of power is connected to a variable-speed reducer which drives a clutch at top left of *Fig.* 2, through a double-strand V-belt. The clutch is direct-coupled to a speed reducer which in turn drives a vertical shaft extending downward into the base of the machine to drive a similar reducer, already referred to, which drives the table.

Clutch is engaged and disengaged by the hand lever located at the right of the machine as shown in *Figs.* 1 and 3. As a safety measure to stop the machine quickly, a horizontal bar extends across the front of the machine. This bar is connected to the clutch for disengagement only. After the machine has been stopped by pressing against the bar the hand lever is required to restart it. Thus when quick action is needed no lost time elapses in reaching for the hand lever since the clutch can be actuated by pressing the bar at any point throughout its length.

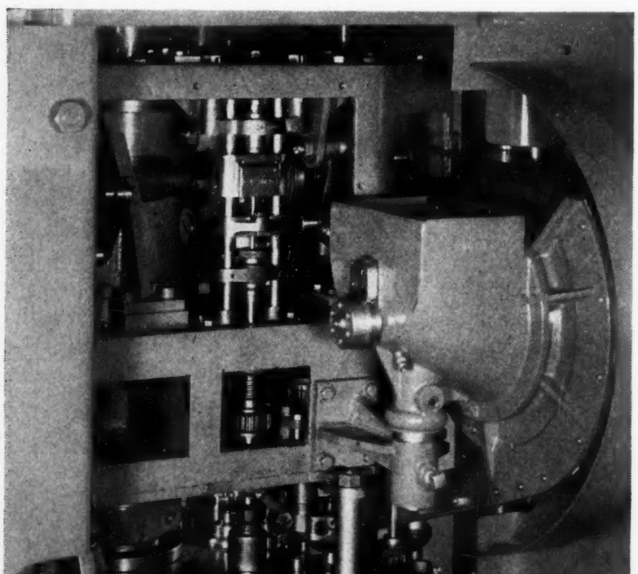


Fig. 4—Rear view shows cap supply hopper at right, final detector at left, and discharge conveyor at lower left

Mechanical Detectors Inspect Parts

The machine is fed manually, the primer tubes being inserted within the collets passing by the attendant, as shown in *Fig.* 3. From then on the tube is under the close inspection of the mechanical detectors. These are of the type common in other automatic machines, particularly those used in the packaging industry. For the most part they are shown in *Figs.* 3 and 4. Referring to *Fig.* 3, the detectors are located at the left of the machine. The first one is the tube height detector. If the tube passes under the finger the detector remains inactive. However, if the tube is too high it will contact the finger and immediately stop the machine.

Second detector inspects the level of the powder. It comprises a rod adapted to enter the tube. If the level of the powder is too high or too low, operation of sensitive mechanism is initiated, disengaging the clutch to stop the machine.

A third detector is used to stop the machine in the event an empty collet passes under the cap-inserting station. This is done to avoid dropping caps into the machine, which would happen if there were no tube in position to receive it.

Final detector is shown in *Fig.* 4, toward the left of the machine. In instances where a cap has not been fully driven into the tube it will be too high to pass under the detector finger. Thus mechanism will be set into motion to stop the machine.

Guards Against Accident

This complete detection system guards against any possible accident or faulty assembling. The performance is outstanding and has led to the remark of one observer: "The machine does everything but talk."

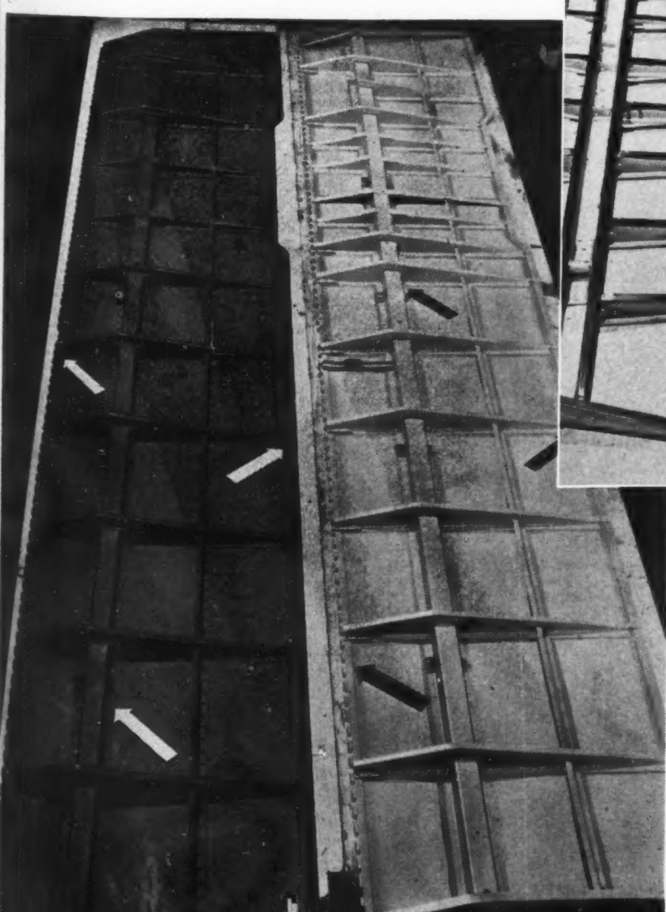
Also shown in *Fig.* 4 is the cap sorter which receives a mass of caps in the supply hopper and discharges them in proper position over a primer tube. In some instances the caps are fed to the delivery chute by hand in order to avoid explosions liable to follow during the tumbling in the sorting wheel.

An ingenious discharge mechanism was developed to remove the completed tube from the collet. This is shown on the right-hand side of *Fig.* 3. A vertically moving chuck grips the tube and draws it out of the collet

(*Concluded on Page* 224)

Scanning the field for IDEAS

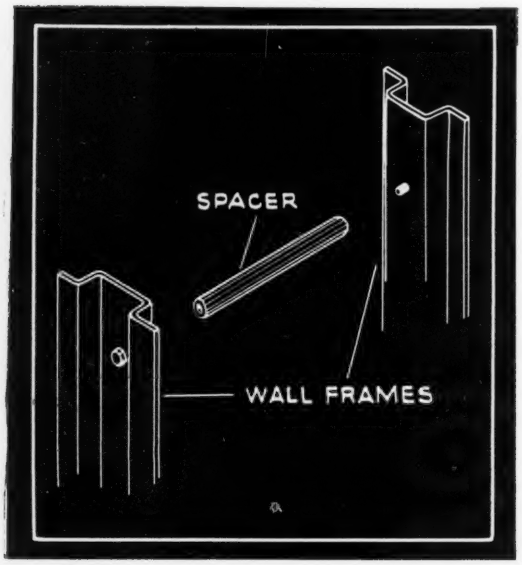
PLASTIC welding of metals and nonmetallic materials by a process known as Cycleweld produces joints for aluminum alloy, wood or rubber especially advantageous in aircraft construction. A specially prepared cement is utilized and is applied to the joint members by brush, spray or tape. In the illustrations below are shown aluminum aircraft sections joined by this method which has been developed by Chrysler in cooperation with the Army, Navy and Goodyear Tire and Rubber Co. Joints are superior to riveted construction and may be applied wherever it is possible to assemble parts with heat and pressure. Recent tests show ultimate shear strength twice that of riveted construction, while impact is many times greater and creep strength 50 per cent more. Stabilizers constructed in this way possess improved rigidity, greater strength and higher fatigue resistance than those fabricated by conventional methods.



Testing accessories before they are completely installed involves the use of special portable equipment which is often laborious and time consuming. Typical of equipment to facilitate such work is a testing unit for hydraulic systems, developed at Curtiss-Wright for use with military aircraft. The heart of the unit,

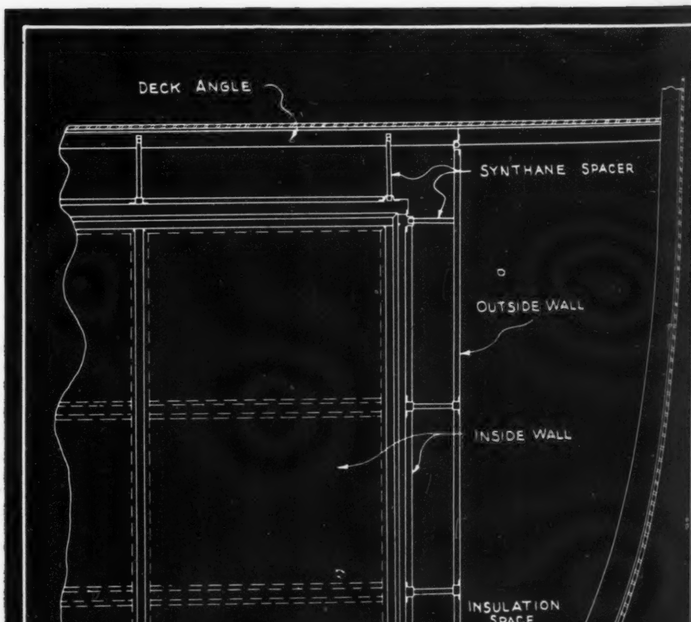
shown at right, is an adapter which permits the use of a standard flange-and-foot electric motor and a standard Wright engine accessory drive gear. Speed of the motors is selected so that accessories may be driven at suitable test speeds. This operation was formerly done with hand pumps, requiring about four hours compared with 30 minutes.

Spacers of synthetic material which has low heat conductivity as well as low moisture absorption facilitates construction of prefabricated metal enclosures for low-temperature applications. Ob-



viating wood furring and all metal-to-metal contact between inside and outside walls, these "pencil" spacers have been developed by Lindsay and Lindsay as shown in the illustrations, above and right, for a marine refrigerator. Similar construction, however would be useful for any insulated space, allowing a full unbroken zone of insulation between the inner and outer walls for increased efficiency.

Shell consists of double, light-steel walls of prefabricated panel-type construction which achieves high strength-weight ratios by stressing under tension the panel sheets between the framing members. Spacers are tubular with ends tapped for fastening bolts as shown in the detail drawing. Phenolic plastics are utilized for the spacers and are placed between adjoining framing members as shown.



Choosing the Right Material

Part I—Physicals vs. Chemical Analysis

By H. W. Gillett
War Metallurgy Committee

SHORTAGE of alloying elements for steel and shortages in nonferrous metals have brought sharply to the fore the problem of conservation and substitution of engineering alloys. The design engineer is faced with the necessity of specifying a new material in place of an old one which experience has proved reasonably adequate for a given purpose. He needs to make the substitution as promptly as possible, but he must have such general information, or make such specific tests, as will afford satisfactory evidence of adequacy.

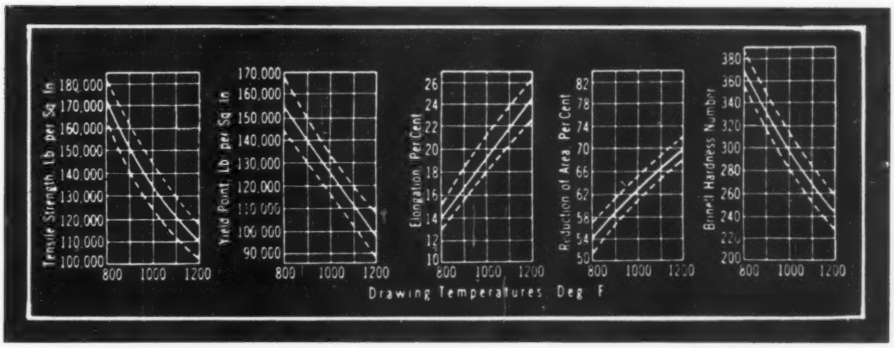


Fig. 1—Scatter bands for tensile properties of SAE 3130

In such a case the engineer has to rely on the metallurgist and the testing engineer for figures, but he still has the responsibility of interpreting the figures and making the final decision. All three may tend to be overconservative and some engineering improvements have come when the engineer, in desperation, tried materials that the metallurgist would not recommend on the basis of his usual methods of evaluation.

Proper evaluation of materials in the light of recent developments and present-day limitations on alloys is a necessity for design engineers. This article, Part I of a series abstracted from a War Metallurgy Committee report prepared at the request of WPB, clearly and concisely interprets the most recent information available. The series constitutes an excellent guide in selection and substitution of materials

It is appreciated that in many cases knowledge is still too hazy and the proper tests still too undeveloped to allow precise solution of all problems, so that evaluation and interpretation often become matters of personal opinion. Expression of personal opinion can be convincing if adequate basis is advanced and, in any case, can be usefully thought-provoking. It has been said "It is worth quite a bit to know how much one does not know."

Materials unquestionably have been used for which adequate and less expensive equivalents can be found by proper testing and evaluation. In war or in peace the aim should be to use each material and each alloying element where it will best serve the engineering necessities. Such use is true conservation. Refraining from use of alloy where refraining leads to an unserviceable product, is waste, just as much as it is waste in war to put in more alloy, or in peace more expensive alloy, than is required to make the product serviceable.

As intensive work as is being done to eliminate unneeded alloys is being done to develop new alloys with hitherto unobtainable properties, even though the alloy requirements turn out to be high, and even for scarce and expensive elements. This is in order to make possible the designing of new instruments of warfare and the introduction of revolutionary economies in peacetime applications. Many such designs are stymied for lack of material that will have the properties the designer knows must be had before his brain-child can exist in concrete form.

The design engineer meets his most difficult problems as to choice of materials when he is designing for strength in *large sections*. It is for such strength that alloy steels

are needed and it is with alloy steels that the path toward conservation and substitution is not as clear as with other materials. The relation of chemical composition to the properties of large, heat-treated steel sections is therefore receiving much attention.

Specification of cast iron and cast steel by chemical composition has long been outmoded. Cast iron is sensitive to the rate of cooling, which of course varies with the size of the section cast, so the same composition gives different properties in different sizes. Hence it is necessary to evaluate and specify cast iron by its mechanical properties, as tested on specimens representative of the size of section being cast.

Cast steel is notably affected as to toughness by the size and distribution of nonmetallic inclusions, which are governed—not by the chemical composition as ordinarily determined—but by small additions of control elements such as aluminum or titanium, put in just as the metal is ready to pour. Few specifications limit the composition of cast steel; only the properties are specified.

Armor, whether cast or wrought, is specified and evaluated on the basis of ballistic tests; the chemical composition may be anything, as long as the tests can be met.

In these cases, unnecessary restrictions upon chemical composition are avoided, but unnecessary restrictions upon the chemical composition of wrought steels to be heat treated are still imposed. This is a remnant of the system of nomenclature in which alloy steels were known by their alloying elements, e.g., as a "chromium-vanadium" steel, or by a S.A.E. number which denoted a particular range of chemical composition. This same practice persists in the nomenclature of the N.E. steels which have been developed as substitutes for S.A.E. steels.

In the case of low-carbon, mild-alloy steels that are to be used without quenching and tempering, it is well recognized that the enhanced strength conferred by the use of alloys can be obtained by a variety of combinations of small amounts of different elements. The War Production Board recognized this and brought about the omission of those compositions that required too liberal use of scarce elements, by refusing to allocate all the necessary alloys.

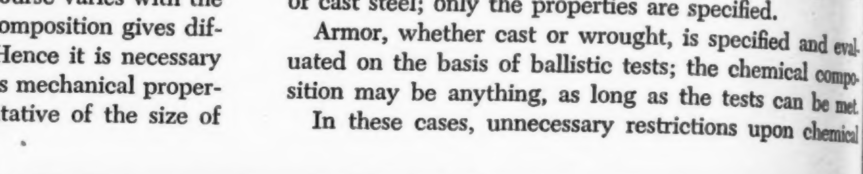


Fig. 2—Right—Scatter bands for SAE 6130 show wide range of physical properties

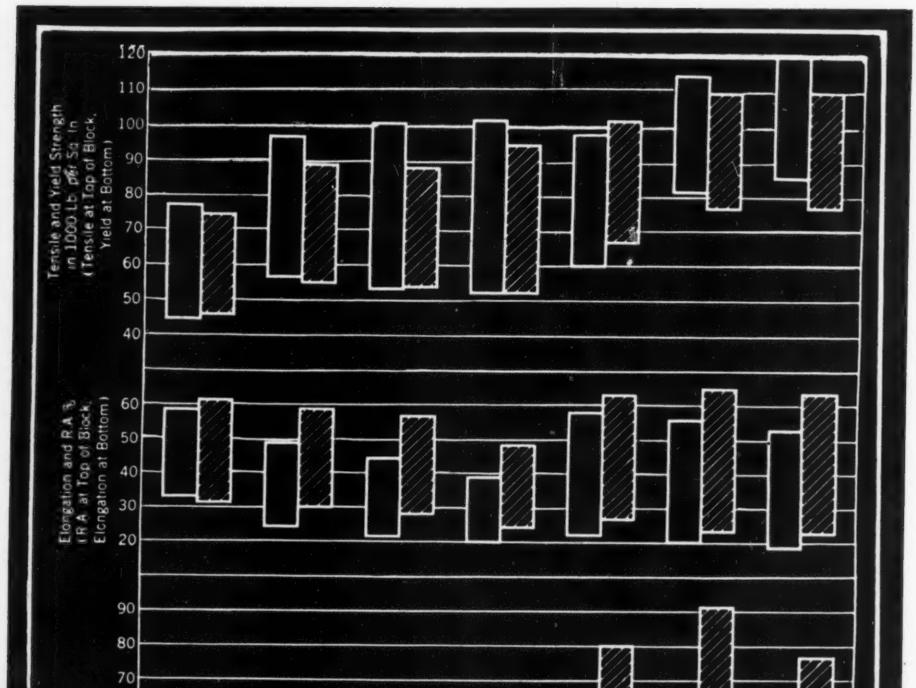


Fig. 3—Left—Effect of grain size on mechanical properties

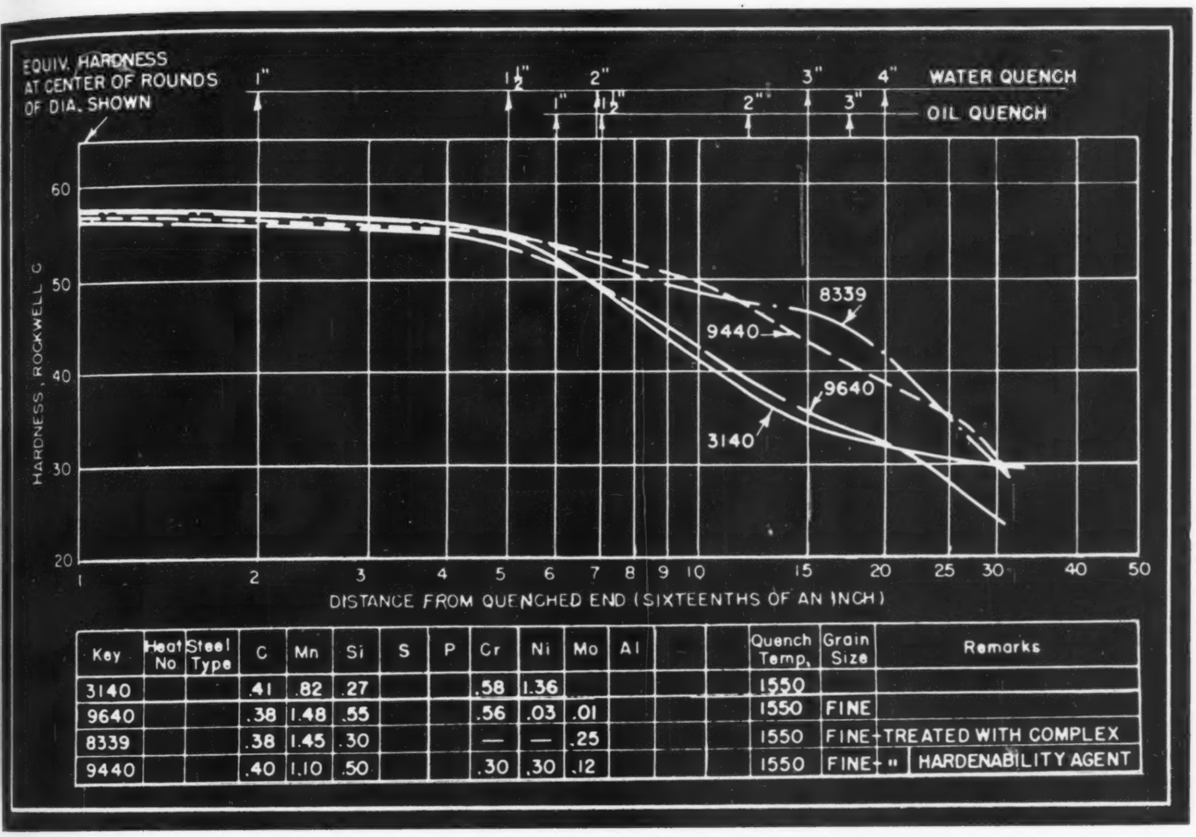


Fig. 4—End-quench hardenability curves for four steels

The Navy, for example, had to accept other steels in place of its well-tried manganese-vanadium steel, in view of the shortage of vanadium.

TABLES I and II show what a variety of compositions have been used commercially to obtain the required 50,000 or 55,000 pounds per square inch yield strength, and also bring out the fact that phosphorus, in amounts not permissible in steels of higher carbon content and barred by steel specifications in general, is a useful alloying element in these low-carbon steels.

Lacy and Gensamer[1] studied the strengthening of carbonless iron upon alloying it with various elements to simulate the alloyed matrix in which the carbides of these non-heat-treated steels are embedded. The plastic deformations, i.e., the stress-strain diagrams of the tensile test, could be made identical. The authors say "It makes no difference whether a curve is obtained by using *X* per cent of element *A* or *Y* per cent of element *B;* if the correct amount of alloying element is used, the flow curves will coincide." That is, chemical composition can be widely varied with identical mechanical results.

Chemical composition counts in steels for corrosion-resistant service, because corrosion is a chemical attack. It counts indirectly in certain types of steels for wear-resistant service, because some alloying elements help to

[1] "The Tensile Properties of Alloyed Ferrites"—Lacy, C. E., and M. Gensamer. Preprint No. 15 for Oct. 1943, meeting American Society for Metals.

TABLE I

Representative Compositions and Corresponding Properties of Low-Alloy Steels for Riveted Structures

(Some Can Be Welded With Suitable Preheating and Stress-Relief Annealing. Usual Requirements, 55,000 Min. Yield, 20% Elong. in 2-in., Up to 1-in. Plate. Longitudinal Specimens. As-rolled ½- to ¾-in. Plate Unless Noted.)

No.	C	Si	Mn	P	Cu	Cr	Ni	Mo	V	Yield Strength (psi)	Tensile Strength (psi)	Elong. 2 in. (%)	Red. of Area (%)	Izod Impact (ft.-lb)
	Composition (per cent)													
1	.28 .35	.25 .15	1.50 1.40	....	.50 .20	....	....	....	....	55,000 to 60,000	80,000 to 90,000	20 to 35	....	40 to 60
2	.30 max.	.50 max.	.90 max.	....	.50	.25 max.	.25 max.	....	....	60,000 to 70,000	75,000 to 90,000	20 20	....	....
3	.20	.20	1.45	....	.20[a]	....	....	....	.12	65,000 to 70,000	90,000 to 95,000	20 to 30	60 to 70	....
4	.17	....	1.00	.09	1.00	....	....	.20	....	55,000	85,000	20	....	....
5	.20	.75	1.25	....	.20[a]	.50	....	....	....	55,000	85,000	20 to 28	50 to 65	....
6	.25	....	1.00	....	1.40	....	.90	.25	....	70,000	90,000	15	....	....
7	.22	....	.80	....	.95	....	1.90	....	....	65,000	90,000	25	55	....

[a] When specified.

Table II

Compositions and Properties of Low-Alloy Steels for Welding Without Preheating or Annealing

(Usual requirements, 50,000 min. yield, 21% Elong. in 8 in. up to 1-in. plate, longitudinal specimens. As-rolled ½- to ¾-in. plate or 1-in. rod unless noted.)

	Approximate Composition (Per Cent)											Elong. (Per Cent)			Impact		
No.	C	Si	Mn	P	Cu	Cr	Ni	Mo	V	Yield (psi)	Tensile (psi)	8″	2″	R. A. (%)	Charpy	Izod	Endurance Limit (psi)
1	.13	.15	.90	...	.20[a]	...	...	.50[b]	...	50,000	80,000	23	..	55	....	....	......
2	.16[d]	.20	1.20	...	.20[a]	...	...	...	.10	60,000	80,000	21	28	60-70	....	60-110	......
3	.14	.70	1.10	...	.20[a]	.50	...	...	...	50,000	75,000	25	..	40	50	....	......
4[c]	.09	.01[e]	1.25	.11	.35	...	...	...	...	50,000	75,000	..	32	55	25	....	......
5	.08	.05	.38	.11	.65	...	.75	.10	...	50,000	70,000	27	..	60	....	130	48,000 (on sheet)
6	.09	.40	.70	.10	.60	.25	.33	...	...	50,000	75,000	25	..	....	....	75	49,000
7	.10	.50	.75	...	.50	.25	.25	...	...	50,000	70,000	25	..	....	....	....	......
8	.10	.30	.60	.10	1.10	...	.55	...	...	50,000	75,000	25	..	60+	55	....	49,000
9	.09	...	.70	...	1.40	...	.80	.10	...	55,000	70,000	25	..	50	25	....	45,000
10	.10	.75	.20	.13	.40	.90	...	...	...	50,000	70,000	..	25	...	40	60	45,000
11[c]	.08	.30	.55	...	1.00	...	2.00	...	...	55,000	75,000	25	..	60	40	....	40,000

[a]Cu content when Cu is desired.
[b]For heavy sections, .25% Mo for light sections.
[c]Atmospheric corrosion resistance greater than for Cu-bearing steel is claimed for steels 4-11.
[d]C content slightly above the usual level for this class, due to fine grain conferred by V. Manufacturers allow .18 C max.
[e]Semi-killed steel.

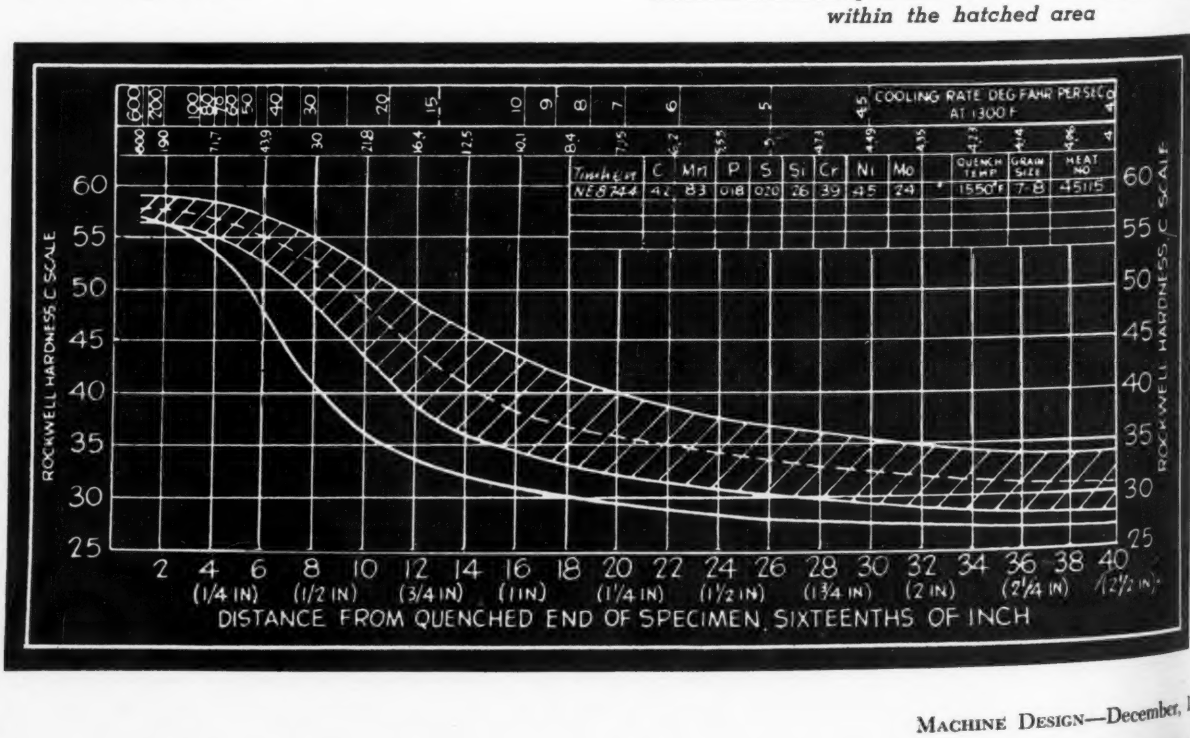
produce specially wear-resistant particles (carbides) of different mechanical properties than those in nonalloyed steel. It counts in the extremely highly alloyed steels used for the most severe high-temperature service, because as yet too little is known about the structure required for best performance in such service to describe it in any other way. Yet, both in the special wear-resisting and the heat-resisting steels there is a considerable degree of replaceability of one element by another.

A clear case of identity of performance, concurrent with identity of structure but unaffected by difference in chemical composition, is met in high-speed tool steel, where molybdenum can be substituted for part or all of the tungsten. Depending on the relative scarcity of tungsten and molybdenum, high-speed steel is made with highly varying amounts of these two elements, yet satisfactory tools are produced.

In the usual, heat-treatable, constructional steels, whose utility depends primarily on mechanical properties of strength and toughness, those properties are essentially conferred *only in an indirect way* by alloying elements.

Great differences in hardenability used to exist among supposedly duplicate heats of S.A.E. steels, falling within the specified ranges of chemical composition. When these differences were not compensated for by variations in tempering, but instead all the different heats were put through exactly the same quenching and tempering treatment, the resultant properties showed much scatter.

Fig. 5—Average hardenability usually obtained for steels within the NE 8744 range of chemical composition is shown by dashed line. Hatched area indicates range of scatter commonly met. Lowest solid line shows the actual hardenability of one heat that was expected to fall within the hatched area



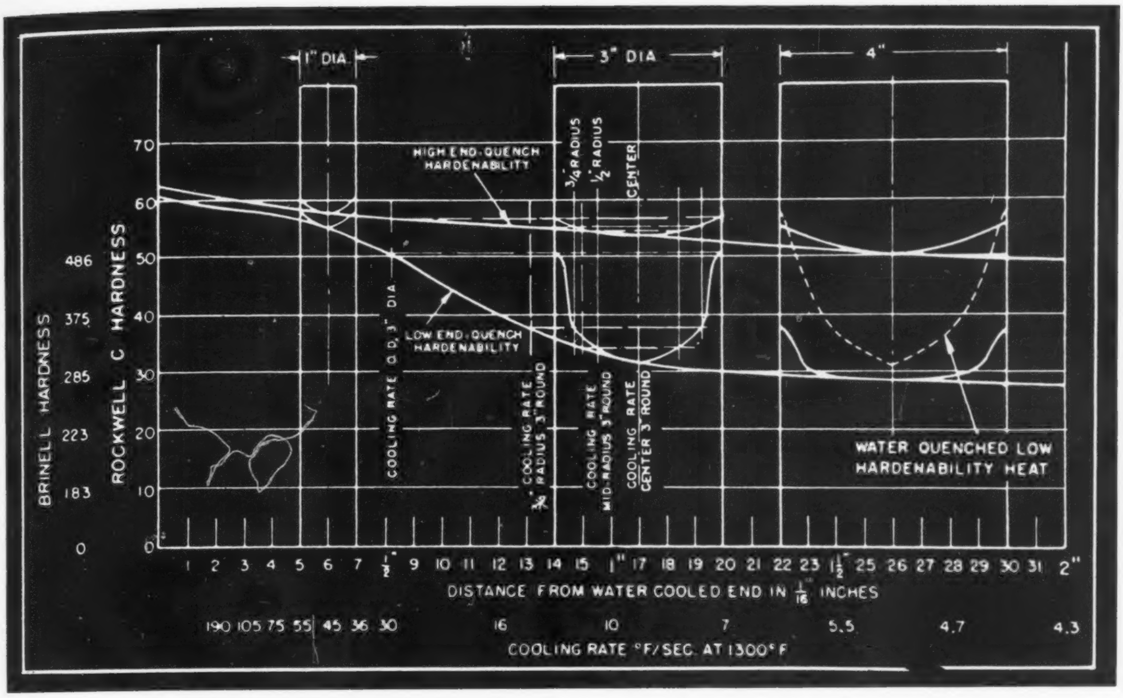


Fig. 6—Curves for high and low-hardenability heats of manganese-chromium-molybdenum steel

Table III illustrates the spread in composition and properties of several heats of four common heat-treatable grades of carbon and alloy steels. These were all heat treated in one-half inch bars to approximately the same tensile strength. The similarity of properties is evident—the spread in properties *from heat to heat* in any one grade is about as wide as between the grades.

Grain Size Is Attribute of Heat

Concern over this situation extends back some fifteen years, when Janitsky[2] summarized, in *Figs.* 1 and 2, the scatter on SAE 3130 and 6130 as then produced. Part of this scatter was doubtless due to variations in finishing practice which produced, sometimes a coarse-grained, sometimes a fine-grained steel. Difference in grain size affects the hardenability and resultant mechanical properties, as shown in *Fig.* 3, after Schane[3]. To avoid this variation it became necessary to supplement the S.A.E. composition range specification with a grain size requirement, since grain size (i.e., grain coarsening propensity) is an attribute of a particular heat, for it depends on the grain control addition (a few hundredths of a per cent of aluminum, titanium, zirconium, vanadium, etc.) which has to be made at exactly the stage when the melt is in condition to respond to it. Chemical analysis of the steel for the addition element does not tell whether the addition was effective; grain-coarsening tests are required.

As experience was gained in the production of fine-grained steels and data were accumulated on their hardenability, it appeared that the fine-grained steels were shallow-hardening and that to secure deep hardening the content of alloying elements would have to be increased to compensate. However, this early generalization later proved incorrect because, in the utilization of some com-

[2]Janitsky, E. J.—"Correlating Test Data on Heat-treated Chromium Vanadium", *S.A.E. Journal*, Vol. 22, 1928, Pages 55-64. "New Physical Property Charts", *S.A.E. Journal*, Vol. 29, 1931, Pages 480-481.

[3]Schane, P. J.—"Effects of Grain Size on Properties and Structure of Steel", *Transactions A.S.M.*, Vol. 22, 1939, Pages 1048-1050.

Table III

Spread in Properties of Four Common Heat-Treatable Steels

Steel	Heat No.	Analyses C	Mn	P	S	Si	Ni	Cr	Mo	Yield Strength, (p.s.i.)	Tensile Strength, (p.s.i.)	Elong. (%)	Reduction of Area (%)	Hardness Rockwell C	
SAE 1040	1	.43	.79	.026	.031	.27	..	..	..	182,000	202,000	14.0	51.1	43	Water quenched from 1500°F., tempered 700°F.
	2	.44	.81	.021	.029	.21	..	..	..	177,000	197,000	14.5	50.3	41	
SAE 2340	1	.42	.59	.018	.018	.22	3.25	..	..	186,000	201,000	14.5	56.3	43	Oil quenched from 1450°F., tempered 800°F.
	2	.41	.70	.032	.023	.25	3.57	..	..	192,000	205,000	10.5	54.2	43	
	3	.38	.78	.019	.029	.24	3.48	..	..	188,000	204,500	15.0	55.1	42	
SAE 4140	1	.43	.72	.026	.021	.28	..	.93	.22	196,000	219,500	13.5	54.1	45	Oil quenched from 1550°F., tempered 800°F.
	2	.40	.70	.016	.033	.23	..	.98	.18	182,000	200,000	10.5	44.0	44	
	3	.43	.68	.018	.029	.23	..	.87	.19	200,000	219,000	13.5	53.3	41	
SAE 5140	1	.39	.84	.020	.022	.24	..	.97	..	173,000	185,900	14.5	58.8	41	Oil quenched from 1550°F., tempered 800°F.
	2	.35	.70	.020	.032	.23	..	.98	..	178,000	192,500	14.5	58.6	41	
	3	.38	.85	.030	.029	.23	..	.86	..	185,000	202,500	14.5	57.0	41	

Table IV

Effect of Addition Agents on Hardenability

Steel	Composition C	Mn	Si	Mo	Ni	Cr	Addition (with or without)	Diameter, Oil Quenching to 50 RC at Center (inch)
C 1341	.38	1.00	...	...	...	...	Without	½
	.43	1.30	...	...	...	...	With	1
N.E. 8442	.40	1.30	.20	.30	...	...	Without	1½
	.45	1.60	.35	.40	...	...	With	3½
N.E. 9440	.38	.90	.40	.08	.20	.20	Without	1
	.43	1.20	.60	.15	.40	.40	With	2

plex grain-control addition alloys, it was noted that sometimes a fine-grained steel had high hardenability. For example, fine-grained steels with and without the use of one of these complex addition agents were recently examined and, by means of hardenability tests, the section noted in which hardening to 50 C rockwell was attained at the center. The results[4] shown in Table IV.

Part of the hardenability of the NE steels for which curves are shown in *Fig.* 4 was obtained by a special addition agent. Obviously, whether the heat is at the high or low end of the specified composition, and whether these addition agents are used or not, make a great difference. Moreover, if the steel is not at the correct condition when the addition is made, the addition may be inoperative. The hardenability may vary with the individual heat. For example, Roush[5] shows *Fig.* 5 for a series of NE 8744 steels which not only showed scatter within the hatched band, for individual heats, but one heat fell away below the ordinarily expected range of scatter. Data are plotted from standard Jominy end-quench hardenability tests.

While hardenability may ordinarily be roughly evaluated by calculation from a complete chemical analysis, cases are cropping up where serious discrepancies are found between calculated and observed hardenability; so the necessity for direct hardenability determinations on individual heats is becoming more and more evident. This is true not only for alloyed, but also for carbon steel. Jameson[6] examined 42 heats of SAE 1045. The *average* hardenability occurred in 29 heats and corresponded to complete hardening by water quenching in ¾-inch diameter. The most hardenable would quench through a slightly larger diameter, but there were four heats that would not harden clear through in ½-inch diameter.

Fig. 6 shows hardenability curves for high and low-hardenability heats of manganese chromium-molybdenum steel. The dotted curve at the right shows that, in a 4-inch section, water instead of oil quenching brought up the surface hardness of the low hardenability heat, but its center was still soft.

This difference in hardenability between different heats points out that hardenability needs to be determined for each heat and not be assumed on the basis of chemical composition.

Ultimately all steel mills may develop rapid methods of hardenability testing that will evaluate the behavior of the steel while it is still molten, so that corrections can be made while there is still opportunity to do something about it. When that day comes, steel of precisely controlled hardenability will be assured, just as steel of controlled grain-coarsening propensity is now obtained with scarcely a miss.

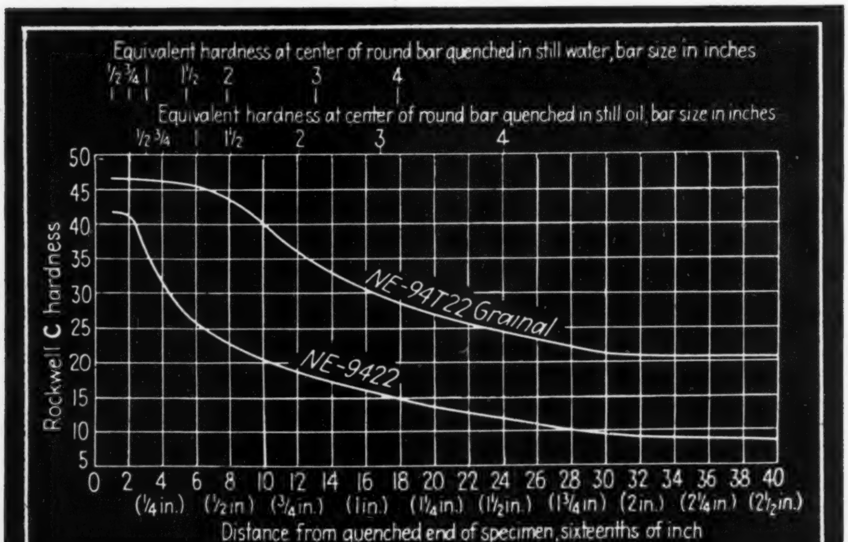
If one compares hardenability data for SAE 3140 and NE 8339, 9440, and 9640 as in *Fig.* 4, it is seen that, for the particular heats tested, and on the criterion that 50 C rockwell denotes sufficiently complete hardenability, the 8339 and 9440 steels will water-quench to that center hardness in about 2¼-inch and 2½-inch diameter, respectively, 3140 and 9640 in 1⅞-inch diameter. When oil-quenched in 2-inch diameter bars, a ring will quench fully in all four, but the center core will be about 48 C rockwell in 8339 and 9440, and only about 40 C rockwell in 3140 and 9640, and the soft core will be larger in the latter two. Thus, if 3140 is adequate in oil-quenched, 2-inch diameter section for a given use, any of the other three should be adequate.

The intensifying action of suitable hardenability agents is brought out[7] in *Fig.* 4 and likewise in *Fig.* 7. The 9422 is a low-carbon steel, with .25 per cent carbon, 1.03 per cent man-

(*Continued on Page 226*)

[4] "Special Alloy Addition Agents, Amer. Iron and Steel Inst.", *Steel*, March 15, 1943, Pages 94-95, 117-120.
[5] "N.E. Steel Handbook and Selector", 1943, published by *Steel*.
[6] Jameson, A. S.—"Plain Carbon Replaces Alloy Steels", *Iron Age*, May 15, 1943, Pages 59-65.
[7] From "Intensifying of NE-9422 Steel", *Iron Age*, Aug. 19, 1943, Pages 50-51.

Fig. 7—Jominy hardenability curves for NE 9422 and NE 94T22 grainal-treated steel, quenched at 1550 degrees Fahr.



Nameplates Are Taboo!

By John W. Greve

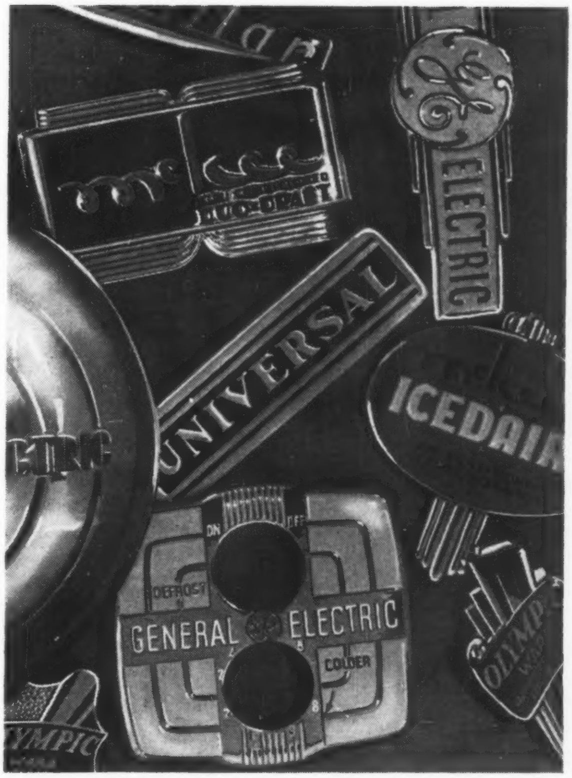


Fig. 1 — Above — Typical group of quality nameplates of embossed type; some are inlaid with vitreous enamels. One is an instruction plate for a refrigerator

DATA plates, instruction plates and nameplates should be selected with care. Because there is a large variety of materials and processes available, each particularly suited to specific types of application, evaluation of plates with respect to suitability and cost is indeed worth while. Also provisions for best locations in keeping with the desired purpose of each plate should be incorporated in the original design to avoid the appearance of an afterthought. All types should be legible for the life of the machine. Plates of quality have a distinct prestige value.

Instruction plates for control knobs, pushbuttons, dials, change gears, etc., are frequently read while a machine is operating. One of the group shown in *Fig.* 1 and the plate shown in Fig. 2 are typical. In use, lighting is often below normal; therefore visibility should be considered.

Data plates such as shown in *Fig.* 3 need not have the "quick visibility" of instruction plates because they are read only occasionally to check rating or model number when ordering replacement parts, or for the manufacturer's name and address. Some instruction plates, such as diagrams (*Fig.* 4), lubrication instructions (*Fig.* 5), etc., also are referred to only occasionally. Considerations applying to data plates apply to such plates except the latter should be displayed more prominently.

Fig. 2—Plate embodies instructions for control circuit. Manufacturer's name is included, obviating a separate data plate or nameplate

The term "nameplate", as such, is restricted to a plate used as a trademark or advertisement for the machine builder. Commonly, all types of plates have been known as nameplates but this should not be done as long as present WPB restrictions on the use of materials are in effect. If, for instance, a data plate were ordered by the purchasing department as a nameplate, restricted materials would be refused. The line of demarkation between nameplates and data plates is a fine one and depends principally upon the purpose of the plate and prominence with which the company name is displayed. Shown in *Fig.* 1 is a group of plates. Generally they are nameplates of the trademark type for which materials at present are highly restricted. One plate in the group, an instruction plate, shows how effectively such a plate may serve the purpose of a nameplate.

Plates—whether nameplates, data plates, instruction plates, etc.—may be classified broadly with respect to the materials from which they are produced. The most common are:

1. Metal
   - a. Brass
   - b. Bronze
   - c. Copper
   - d. Aluminum
   - e. Zinc
   - f. Steel
   - g. Stainless
   - h. Monel
2. Enamel
3. Glass
4. Photographic transfers
5. Plastic
   - a. Laminated sheet—phenolic
   - b. Molded—thermosetting
6. Decalcomania transfers

Metal plates may be etched, lithographed, embossed,

engraved or, for the nonferrous group, cast. Engraving, being an expensive process, is generally applied only where unusual accuracy is required. Metal for all types of plates is highly restricted. None of the metals tabulated may be used for nameplates except steel and stainless—and these only for orders approved by WPB. In the case of stainless, it may be used only for "Army-Navy-Maritime orders" and must be procured through the surplus Inventory Branch, Iron and Steel Division of the War Production Board which has assumed the duties of the former Steel Recovery corporation.

For other types of plates, restrictions are not as severe. Brass and bronze because of tin content are not, however, being used. Copper also is highly restricted—military exemptions listed in order M-9-c allows use for "instruction and data plates of wrought material of a gage of 1/32-inch or less (for use in aircraft and on board ship). Instruction and data plates from cast material of a gage of 3/32-inch or less for use on board ship but only if and to the extent specified by the specifications, other than performance specifications, of the governmental agency acquiring the plate."

Use of aluminum is permitted when a less scarce material is not practicable. Order M-1-i permits use for "data and instruction plates, provided that the thickness does not exceed .035-inch and the plate is no larger than required to present the essential data and instructions". Included are dials, scales and panels for mechanical and electrical instruments.

Zinc may be used in the manufacture of data and instruction plates in compliance with order M-11-b: "Under a specific contract or subcontract covering the manufacture of any product, or any component to be physically incorporated into such product, produced by or for the account of the Army or Navy of the United States, the United States Maritime Commission, or the War Shipping Administration to the extent required by specifications, applicable to the contract, subcontract or purchase order."

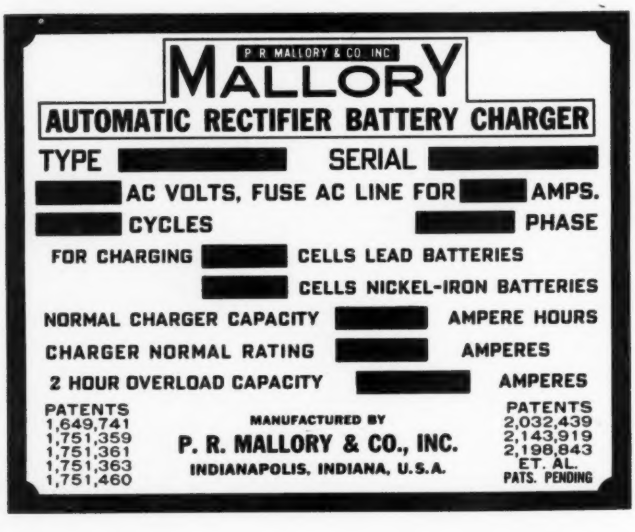


Fig. 3—Above—General form of data plate on which information for specific unit may be stamped

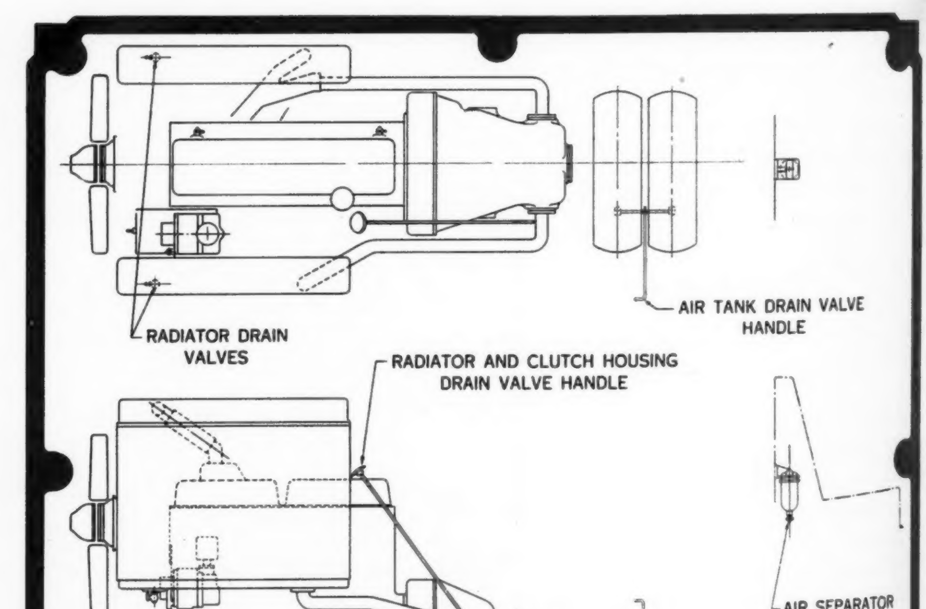


Fig. 4—Instruction plate of the diagram type which may be referred to when machine needs servicing

Monel is not being used because more available materials can be applied. The situation with respect to nickel alloys, however, is expected to ease during the next year and postwar designs may contemplate their use.

Steel is not satisfactory unless it is protected with a coating or plating. Some companies have attempted to silver-flash data plates, but generally the plates have not been too successful. Conventional plating of gold, silver, chromium, nickel, cadmium and copper, as well as lacquering and enameling of both the low-baked and hard-fired types, is highly successful for protective purposes and also provides decorative effects.

Any of the regulations with respect to metals may be changed on short notice, being dependent upon supply and demand.

Postwar designs need not be restricted with respect to

Fig. 5—Lubrication instruction plate carries full details for maintenance

decorative nameplates as shown in *Fig.* 1. There is practically no limit to the intricacy that may enter into the design of die-struck plates, permitting the designer freedom to create a distinctive "signature". Because special embossing dies are required for this type of plate, its use is not practical when the number to be produced is small. In quantities of 300 or 400, embossed plates are usually considered moderately expensive. Larger quantities, however, are economical.

Embossed plates are especially adapted to use on equipment which is retailed to individual consumers. Pride of ownership is a determining factor in many purchases of this type and the nameplate is an important factor in consumer appraisal. Embossed plates, however, are not especially suitable for instruction or data plates because of the fine lettering usually employed and the difficulty of reproducing them by this method.

Vitreous enamel on embossed plates offers unlimited opportunities for developing attractively colored plates. Bright, rich colors used as inlays produce distinctive results of a high quality. One base metal used for this purpose is a special bronze consisting of 90 per cent copper and 10 per cent zinc. Being resistant to corrosive attack, the enamel remains bright and lustrous.

Imprinted enamel on sheet stock is widely used for instrument dials, as shown in *Fig.* 6, effecting a highly legible and durable surface. If enameled dials or plates are subject to abuse a sheet steel base, sufficiently strong to prevent chipping, should be utilized.

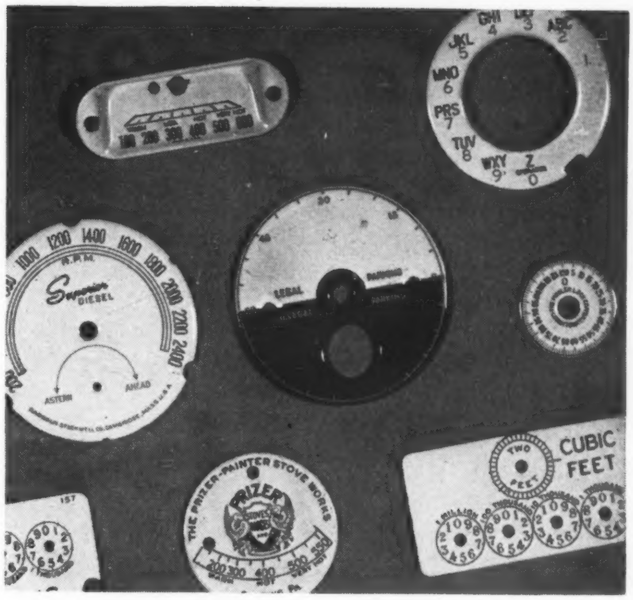


Fig. 6—Imprinted dials utilizing vitreous enamel surfaces

Glass, either clear or translucent with printed characters, has recently received increased attention both because of economies in design and the possibilities for modern back lighting. Panels for signal lights with various instructions lighting up for different signal lights produce neat, attractive and economical designs. Dials or scales for indicator pointers such as used on radios have wide possibilities for application especially where readability and easily cleaned surfaces are desired.

Photographic Transfers Are Useful

Photographic transfers are particularly adaptable for reproducing intricate wiring diagrams for instruction plates or other information, especially of the types that are not easily reproduced. Images usually are restricted to the black silver commonly employed. Special paper with photographic emulsion is laminated to a base material such as steel, bronze, aluminum and plastic sheeting to give it the necessary body required. If a transparent background is desired, a special primer is employed for laminating to a transparent base. Protection of the processed image is obtained by dipping in a lacquer and allowing to dry at room temperature. Stability to obviate possible future checking of the coating is obtained by curing for 12 hours in a drying oven at 120 to 130 degrees Fahr. Checking is most likely to occur when the laminated article is submitted to temperatures around 175 degrees. Such checking results from the fact that all the solvents may not have been thoroughly dried out of the laminating and overcoating lacquers.

A subsequent article will discuss the applications of plastic plates and decalcomanias with respect to recent developments and possibilities for these materials for different classes of equipment.

Co-operation of the following companies in supplying information and illustrations for this article is acknowledged. American Emb'em Co., Utica, N. Y. (*Fig.* 1); Crowe Name Plate & Manufacturing Co., Chicago, (*Figs.* 2, 3, 4, 5); Eastman Kodak Co., Rochester, N. Y.; Fox Co., Cincinnati; Horace R. Whittier Co., Pequabuck, Conn. (*Fig.* 6).

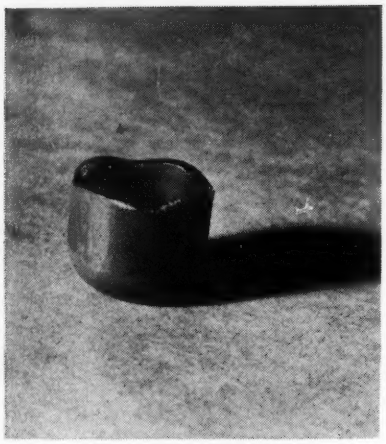
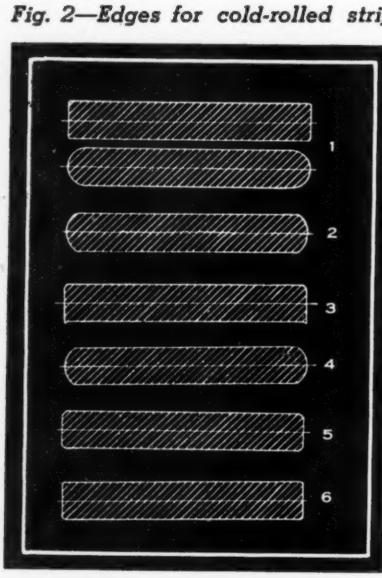


Fig. 1—Ears on drawn cup

Fig. 2—Edges for cold-rolled strip



Strip Steel—Spec

By W. F. Carter
Acme Steel Co., Chicago

BECAUSE light-gage, flat-rolled steel is widely used in roll forming, brake, bending roll and press-production methods, an evaluation of commercial grades available with respect to fabrication requirements is particularly helpful for specification of the most economical material for a given purpose. Although alloy steels are produced in sheet and strip form, this article will be confined to hot and cold-rolled carbon grades. Alloys are not used as abundantly and their applications, at present, are highly restricted.

Light-gage, flat-rolled products are considered as sheet or strip depending upon the width, gage, finish, edge and temper specified. TABLE I is the American Iron and Steel Institute standard for hot-rolled steel, while TABLE II is standard for cold-rolled steel. Sheet and strip are produced in either a hot or cold-rolled finish with or without nonferrous coatings.

Hot-rolled material is characterized by an oxide coating resulting from preforming the final rolling operation at a temperature which produces a scale or by a relatively dull, rough surface which results from a pickling operation to remove the oxide coating. Cold-rolled material is produced by subjecting pickled hot-rolled steel to further rolling at a temperature below the point at which scale will form. Cold-rolled materials have an oxide free, bright finish.

Cold-rolled steel may be selected for any one or a combination of the following reasons: To obtain a better finish and closer dimensional tolerances; to obtain special tempers for higher strength, free blanking or better machinability; and to obtain sections too thin to be hot rolled. Comparison of standard-gage tolerances for hot and cold-rolled strip is shown in TABLES III and IV, respectively.

Steel for rolling into sheet or strip may be open-hearth, bessemer, or electric furnace products under either acid or basic practice. The great bulk is open-hearth and a rimming practice is used in the ingot molds. This produces a steel with a surface of high purity, relatively free from surface defects such as "seams" and "slivers". Special killed steels are employed when the application requires that the material be pattern-free after a deep etch of the cross section, or be free from "aging". Aging phenomena will be discussed more fully later.

Sheet

HOT-ROLLED—Three classes of hot-rolled sheets carry a hot-mill oxide. They may be annealed or flattened by light cold rolling or roller leveling. Commercial quality sheet is suitable for ordinary purposes where the oxide is not objectionable on the finished part or does not interfere with fabrication. This material, in carbon ranges not exceeding .15 per cent, will withstand being bent flat on itself in any direction and then being doubled flat with the fold in the opposite direction. Special-surface quality sheet has the same bend test and physical properties but is subjected to more rigid inspection in the mill for surface defects. Physical-quality sheet meets physical properties beyond the bend test of commercial. These include tensile tests and properties desired in pressing or drawing into definite stampings or in eliminating surface disturbances such as

TABLE I

Standard Classification by Size of Hot-Rolled Carbon Steel

Width (inch)	Thickness (inch) Up to .0141	.0142 to .0254	.0255 to .0343	.0344 to .0567	.0568 to .1874	.1875 to .2030	.2031 to .2490	.2500 and thicker
Up to 3½	Sheet	Sheet	Strip	Strip	Strip	Strip	Bar	Bar
>3½ to 6	Sheet	Sheet	Sheet	Strip	Strip	Strip	Bar	Bar
>6 to 12	Sheet	Sheet	Sheet	Sheet	Strip	Strip	Strip	Plate
>12 to 32	Bl. Pl.*	Sheet	Sheet	Sheet	Sheet	Sheet	Sheet	Plate
>32 to 48	Sheet	Sheet	Sheet	Sheet	Sheet	Sheet	Sheet	Plate
>48	....	Sheet	Sheet	Sheet	Sheet	Plate	Plate	Plate

*Black plate.

To Fit the Job

stretcher strains and fluting. This material should be specified for all difficult parts fabricated from hot-rolled sheets.

Hot-Rolled Pickled—Pickled sheets are, in general, similar to hot-rolled sheets except that they are subjected to additional operations to remove the oxide coating. This is usually accomplished through pickling either before or after annealing and then flattening by light cold rolling or roller leveling. Hot-rolled pickled commercial-quality sheet is suitable for ordinary purposes where an oxide coating is objectionable. It will meet the same bend test as standard commercial quality. Pickled physical-quality sheet is used when an oxide coating is objectionable and physicals other than the bend tests of hot-rolled commercial quality are required, including tensile tests and those required to control temper closely. Drawing quality is produced for use on parts where suitability for deep drawing is the primary requirement.

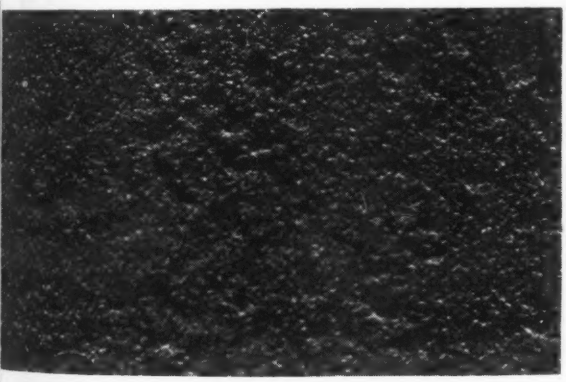


Fig. 3—Specially roughened surface for a difficult draw job, magnification 4 diameters

Such sheets are usually furnished in a dead-soft condition and are subject to stretcher strains.

Cold-Rolled—There are three classes of cold-rolled sheet steels. Commercial quality is suitable for exposed parts requiring excellent surface. This quality is nonfluting and is free from other surface disturbances if roller leveled immediately before use. Sheets of this quality will bend flat on themselves in any direction and are satisfactory for moderate drawing. Luster-surface quality is produced on ground and polished cold rolls and has a brighter finish than commercial quality. Deep-drawing quality is produced to meet the most severe drawing requirements including those which require a smooth surface free from stretcher strains after drawing.

Edges—Sheet steels are produced with either mill edges or sheared edges. A mill edge is one resulting from the normal rolling operation and does not conform to any definite contour.

Finishes—Sheet steels may be obtained with a number of coatings such as oiled, limed, galvanized, terne coated, and blued.

Table II

Standard Classification by Size of Cold-Rolled Carbon Steel

Width (inch)	Thickness (inch) Up to .0141	.0142 to .2499	.250 and Up
Up to 12	Strip[3]	Strip[3]	....
>12 to 24	Strip[1]	Strip[1]	Strip[1]
>12 to 24	....	Sheet[2]	Sheet[2]
>24 to 32	....	Sheet	Sheet
>32	Sheet	Sheet	Sheet

[1] When a particular temper as defined in ASTM A109, or a special edge, or special finish is specified.

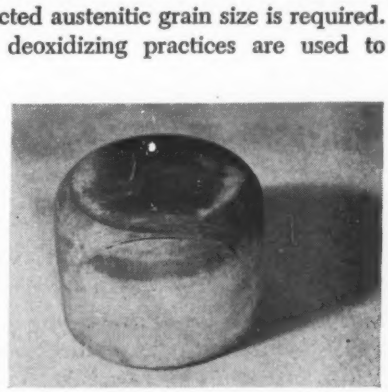
[2] When no special temper, edge, or finish is specified.

[3] When the width is greater than the thickness with a maximum width of ½-inch and a cross section area not exceeding .05 square inch, and the material has rolled or prepared edges, it is classified as flat wire.

Quality—Hot-rolled strip is produced in two classifications, namely ordinary and special quality. Ordinary quality is made in all carbon ranges up to and including .25 per cent maximum. This strip is suitable for all ordinary purposes. It will bend flat on itself in any direction in analyses up to .15 maximum carbon. In carbon ranges of .16 to .25 per cent carbon, strip of this quality will bend around a mandrel equal in diameter to the thickness of the specimen.

Special-quality embodies all the grades made to meet special requirements such as austenitic grain size, forging quality, nonscalloping, and extra-deep drawing qualities. Nonscalloping properties are produced by processing and heat treatments to eliminate any marked degree of "ears" on the edges of drawn articles. *Fig.* 1 illustrates an extreme case of earing. Deep-drawing quality is usually a specially selected steel, subjected to extra discard and annealing operations to produce a material suitable for severe drawing operations. Forging quality is produced in hot-top ingot molds and is subjected to special practices with respect to discard and surface conditioning to obtain a high degree of internal soundness and chemical homogeneity and freedom from surface defects. Special carburizing quality is for the manufacture of heat-treated parts in which a restricted austenitic grain size is required. Special furnace and deoxidizing practices are used to

Fig. 4—Defective cup resulting from deeply scratched raw material



control the grain size to ranges of not less than three grain size numbers in sequence.

EDGES—Hot-rolled strip is made with three types of edges. Mill edge strip is generally used when the part or fabricating operations do not require the smaller width variations obtainable in slit-edge strip or where the natural round mill edge forms a part of the finished article and is more desirable than the square contour of a slit edge. Slit-edge strip is used when the part or fabricating operations require accuracy of width or a square-edge material. Square-edge strip is produced in a limited range of sizes by hot-edge rolling. This is used when material without sharp corners is desired and mill-edge width variations are permissible.

Hot-Rolled Strip

FINISH—Hot-rolled strip is supplied in plain finish carrying an oxide coating or in pickled finish with or without coatings of oil or lime to prevent rusting and

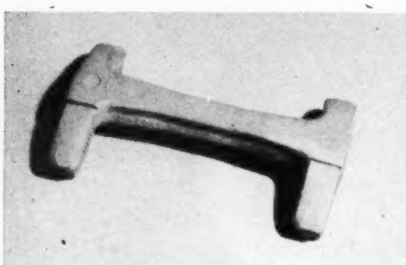


Fig. 5 — Left — Failure due to a seam in material

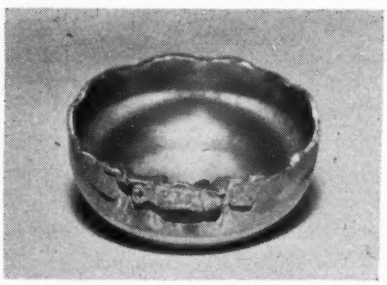


Fig. 6—Right—Cup drawn from piped or laminated steel

to act as a lubricant to dies and other tools. Plain hot-rolled is suitable for a wide variety of parts where surface finish is not important. It should not be used for parts whose fabrication involves cold drawing as the oxide has an abrasive effect on tools. Pickled strip is suitable for drawn parts on which surface finish is not important.

Cold-Rolled Strip

Cold-rolled strip is manufactured in the size ranges shown in TABLE II and in five temper classifications depending on the degree of hardness and on the ductility required.

TEMPERS—The tempers of other than "dead soft" are produced by varying amounts of cold rolling subsequent to a prior cold rolling and annealing operation. The extent of the cold reduction varies throughout the industry so that the percentage of reduction for each temper cannot be given. In all cases, however, the harder tempers are produced by larger reductions after the final anneal. When maximum softness is required the material is an-

TABLE III

Standard Permissible Variation in the Thickness of Hot-Rolled Strip Steel

Width (inch)	Permissible Variation* for Given Thickness (inch) .0255 to .0343	.0344 to .0567	.0568 to .1179	.1180 to .1874	.187[illegible] to .249[illegible]
Up to 3½	.003	.003	.004	.005	.00[illegible]
>3½ to 6	...	.003	.005	.005	.00[illegible]
>6 to 12	...	...	.005	.005	.00[illegible]

Width (inch)	Crown Tolerance† (max. in.)
Up to 5	.002
>5 to 10	.003
>10 to 12	.004

* Thickness measurements are taken ⅜-inch from edge of strip. Va[riation] from specified thickness for widths given. Over or under gi[ven] variations do not include crown.

† Strip steel may be thicker at the center than at the edge by t[he] amounts shown.

nealed in the final operation and is known as No. 5 o[r] dead-soft temper. TABLE V lists the various tempers an[d] gives the approximate hardness limits and tensile strength of each.

No. 1 or hard temper is a hard cold-rolled product suitable for flatwork only; it is not suitable for manufacturing any part which requires bending

No. 2 or half-hard temper is a moderately hard, cold-rolled material suitable for easy bending; it is capable of being bent to a 90-degree angle around a radius equal to the thickness of the test piece

No. 3 or quarter-hard temper is a medium-soft, cold-rolled product suitable for forming, bending and easy drawing; it can be bent flat on itself across the grain and with the grain to a 90-degree angle around a radius equal to the thickness of the test piece

No. 4 or soft temper is a soft, ductile cold-rolled product suitable for fairly deep drawing when no sign of surface disturbance such as drawing strain is permissible; it is capable of being bent flat on itself with or across the grain

No. 5 or dead-soft temper is a soft, ductile, cold-rolled product suitable for difficult drawing operations in which surface disturbances such as stretcher strains are not objectionable; it is capable of being bent flat on itself with or across the grain.

EDGES—Cold-rolled strip is ordinarily produced wi[th] one of three types of edges. These are commonly de[-] signated as No. 2, No. 3 and No. 4. Other edges whic[h] may be produced with special manufacturing practice are No. 1, No. 5 and No. 6. The following description are those commonly given for the edges while Fig. [7] illustrates the approximate shape of each.

No. 1 Edge is rolled, either round or square, supplied when a very uniform width is required and where the finish of the edge must be suitable for plating

No. 2 Edge is a natural, round mill edge carried through from the hot-rolled strip

No. 3 Edge is approximately square, produced by slitting

No. 4 Edge is round, produced by edge rolling No. 2 or No. 3 edge material, and is used when an

approximately round edge is desired and where its finish is not important

No. 5 Edge is approximately square, produced by rolling or filing after slitting to remove the slitting burr only

No. 6 Edge is square, produced generally by edge rolling square edge hot-rolled strip where the width tolerance and finish required are not as exacting as for the No. 1 edge.

FINISHES—Cold-rolled strip is furnished with three standard types of uncoated finishes which are usually

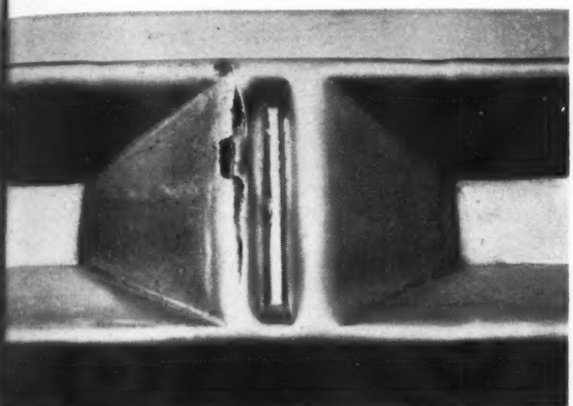


Fig. 7—Failure due to piped steel

designated as No. 1 or dull, No. 2 or commercial bright, and No. 3 or best bright.

The No. 1 finish is produced by final rolling on a mechanically or chemically roughened roll. This finish gives improved lacquer or paint adherence and is also beneficial in drawing operations as the surface irregularities serve to carry lubricant into the dies and reduce contact friction between the steel and the dies. *Fig.* 3 illustrates an extremely rough surface which is being used successfully in a difficult cupping and drawing operation. Marked improvement in die life and elimination of scoring resulted when this surface was substituted for the commercial finish.

The No. 2 finish is produced by final rolling on a smooth ground roll. It has a semigloss finish suitable for average requirements.

No. 3 finish is produced by final rolling on a highly polished roll preceded by special rolling practices in all stages. It is the best quality finish obtainable and is suitable for electroplating without buffing.

Cold-rolled strip is also produced with nonferrous coatings such as galvanized, tinned, terne coated, copper plated, nickel plated and lacquered. Any of the metallic coatings may also be lacquered or painted.

Common Defects

In *Fig.* 1 is illustrated a condition commonly referred to as "ears" or "scallops". This results from directional properties in the stock and is characterized by the regularly spaced high and low areas around the top edge of the cup. This may occur in various degrees, the case illustrated being an extreme one. In drawing practice an allowance in blank size is necessary to compensate for these irregularities unless a nonscalloping material is used. Material of this type is processed to produce uniform properties in all directions relative to the direction of rolling, thereby eliminating any marked degree of unevenness on the top edge. It is good practice, however, to use a trim operation on all parts requiring a straight top edge irrespective of the type of material used.

A defective part resulting from material containing a deep scratch is illustrated in *Fig.* 4. Scratches may originate at any point in the rolling, shipping or other handling of the material, including handling into or through the fabricating operations. It is evident in the photo that the notch created by the scratch has resulted in rupture.

Seams are another source of failure. These defects occur as small crevices or fissures extending parallel to the direction of rolling. They result from a "lap" formed in the rolling or from the opening up during the rolling operation of a crack or blowhole in the original ingot. They are frequently confused with scratches as the two defects may appear similar. *Fig.* 5 illustrates a typical fracture which occurred as a result of a seam on the outside of a slightly bent surface.

Another common defect results from "piped" steel as shown in *Figs.* 6 and 7. Steel containing this type of defect is also called "laminated" because of its laminar appearance. This condition is a result of shrinkage cavities or blowholes in the ingot which have been closed up in rolling without effecting a weld. The defect is usually confined to the upper portion of the ingot and can be removed by shearing sufficient discard off the ingot during the rolling operation. Special pouring and mold practices may be used to eliminate or control the location

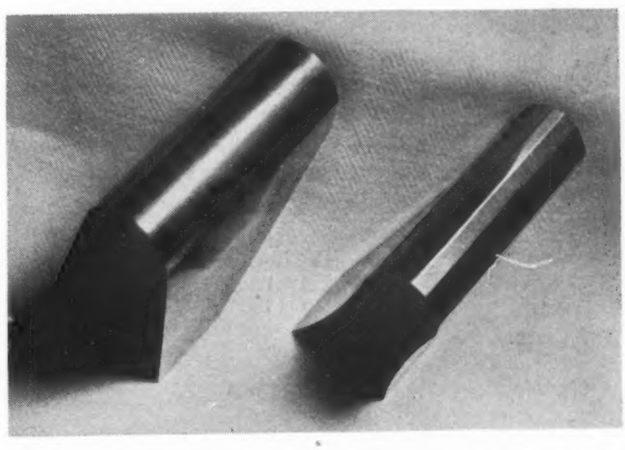


Fig. 8—Smooth bend formed with temper-rolled material, left; fluted bend obtained with dead soft material, right

of shrinkage cavities so they can be completely removed with a minimum of discard.

A condition such as shown at the right of *Fig.* 8 is commonly referred to as "fluting". This sample was prepared by bending a dead soft steel around a mandrel. The sample on the left is the same piece of steel after it had been given a light cold rolling. Low-carbon steels in the annealed condition (dead soft or No. 5 temper) will bend in the manner illustrated at the right. All other tempers will form a uniform bend as shown at left.

Stretcher strains, as mentioned previously, are another

Table IV
Standard Permissible Variations in the Thickness of Cold-Rolled Strip Steel

Ordered Thickness (inch)	Permissible Variation* for Width Range† (±inch): 3/16 to < 1	1 to < 3	3 to 6	> 6 to 9	> 9 to 12	> 12 to 16	> 16 to 20	> 20 to 24
.010	.001	.001	.001	.001	.001	.001	.001	.001
.011	.001	.001	.001	.001	.001	.001	.001	.001
.012	.001	.001	.001	.001	.0015	.0015	.0015	.0015
.013 to .014	.001	.001	.001	.0015	.0015	.0015	.0015	.0015
.015 to .016	.001	.001	.001	.0015	.0015	.0015	.0015	.0015
.017 to .019	.001	.001	.001	.0015	.0015	.0015	.0015	.0015
.020 to .022	.001	.001	.0015	.0015	.0015	.002	.002	.002
.023 to .025	.001	.001	.0015	.0015	.0015	.002	.002	.002
.026 to .028	.001	.0015	.0015	.002	.002	.002	.002	.002
.029 to .031	.0015	.0015	.0015	.002	.002	.002	.002	.002
.032 to .034	.0015	.0015	.002	.002	.002	.002	.002	.002
.035 to .039	.002	.002	.002	.002	.002	.002	.002	.002
.040 to .049	.002	.002	.0025	.0025	.0025	.003	.003	.003
.050 to .068	.002	.002	.0025	.0025	.0025	.003	.0035	.0035
.069 to .099	.002	.002	.0025	.003	.003	.0035	.0035	.0035
.100 to .160	.002	.002	.003	.003	.003	.0035	.0045	.005
.161 to .249	.002	.003	.0035	.0035	.0035	.0045	.005	.005

Thickness (inch)	Crown Tolerance§ (inch): Up to 5	> 5 to 12	> 12 to 24
.005 to .010	.00075	.001	.0015
> .010 to .025	.001	.0015	.002
> .025 to .065	.0015	.002	.0025
> .065 to .187	.002	.0025	.003
> .187 to .250	.002	.0025	.003

* Measured ⅜-inch in from edge on 1-inch or wider; and on narrower than 1-inch at any place on the strip.

† Apply only on 6 inches and narrower: .009-inch to .006-inch plus or minus .00075-inch under .006-inch plus or minus .00050-inch.

§ Tolerance for thickness at center of strip shall be that for the edge measurement plus the values tabulated.

source of difficulty when drawing dead-soft material. These strains are illustrated in *Fig.* 9. Both stretcher strains and fluting are a result of local plastic deformation. Stretcher strains exist on tensile test specimens which have been stretched from 1.5 to 10 per cent and their appearance is due to a reduction in thickness. Overstraining results at elongations beyond about 10 per cent and the material becomes uniformly reduced in thickness, causing the stretcher strains to disappear.

The sample in *Fig.* 9 was prepared by drawing an Ericksen test cup in a piece of annealed material which had been blued to accentuate the condition for purposes of photographing. *Fig.* 10 shows the same steel which

Table V
Carbon Content, Hardness and Tensile Strength of Cold-Rolled Tempers*

Temper	Common Carbon Limit (%)	Approximate Rockwell "B" Limit	Approximate Tensile Strength (psi)	Elong. in 2 inches for .050-in. Strip (%)
No 1—Hard	.25 max.	B84 min. for >.070-in B90 min. for <.070-in.	80,000±12,000	3±2
No. 2—Half hard	.25 max.	B75 to 85	64,000± 8,000	9±5
No. 3—Quarter hard	.15 max.	B65 to 75	54,000± 6,000	20±7
No. 4—Soft or planished	.15	B65 max.	48,000± 5,000	30±6
No. 5—Dead soft	.15 max.	B55 max.	44,000± 4,000	39±6

* These values are given as information only and are not intended as criteria for acceptance or rejection of material.

has been given a light cold rolling before forming.

When maximum ductility is desired and fluting or stretcher strains are objectionable, a soft or roller-leveled material should be used. Another practice to eliminate this trouble utilizes dead soft material roller-leveled immediately before forming. This is the safer practice as stretcher strains and fluting will in time return in material which has been processed to eliminate them. The return of these defects is due to aging. This term covers phenomena which bring about changes in physical properties which occur in cold-worked low-carbon material at room or slightly elevated temperatures with the passage of time. The phenomena is more correctly called "strain aging" to differentiate it from the changes which occur in quenched materials.

Aging has never been completely explained but it is believed to be related to the presence and precipitation

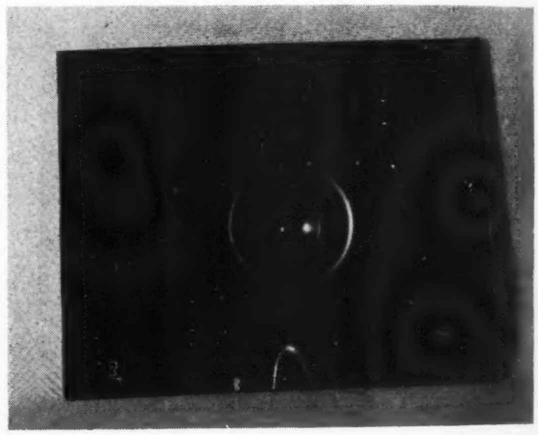
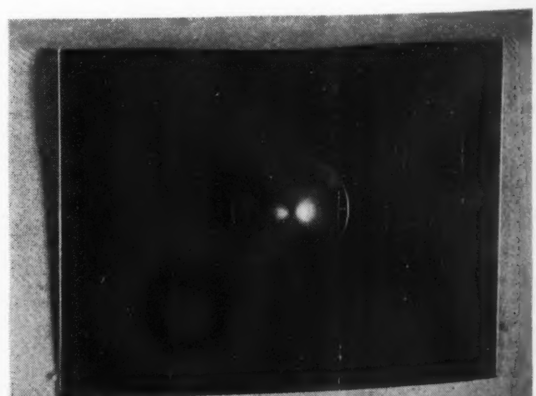


Fig. 9—Stretcher strains in dead-soft steel

Fig. 10—Below—Surface obtained on the same material as shown in Fig. 9, when temper rolled before forming the cup



of some constituent. Various investigators have attributed it to the precipitation of carbides, oxygen, nitrogen and hydrogen. There is general agreement on the fact that cold working causes a solute material to go into solution and that it will precipitate under favorable time and temperature conditions and cause a change in properties. Increasing amounts of cold working and low temperatures of storage retard aging. Small amounts of cold

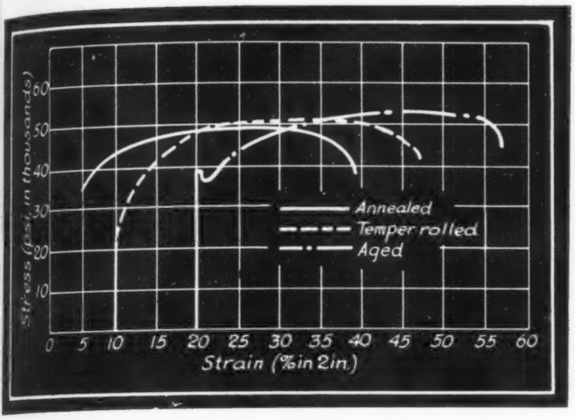


Fig. 11—Stress-strain curves of low-carbon steel in the annealed condition, temper rolled condition and after aging

work and elevated temperatures accelerate it.

While the exact mechanism is not clearly understood, the effects of aging have been subject to much investigation. It is generally agreed that aging results in an increase in hardness, yield and tensile strength, and a decrease in ductility and impact strength. It will also bring about a return of stretcher strains and fluting.

Shapes of stress-strain diagrams of annealed, cold-worked, and cold-worked and aged steels are shown in *Fig.* 11. The sharp yield point characteristic of annealed low-carbon steels has returned in the aged material. Steels exhibiting this type of yield point will always draw with stretcher strains. Freshly cold-worked steels produce a smooth stress-strain curve and do not form stretcher strains.

Special killed steels commonly referred to as nonaging or stabilized are produced to eliminate the difficulties caused by aging. The use of these steels is advisable for extremely difficult draws where cold working of ordinary material to eliminate aging results in losses of ductility to an extent which will cause failure in the forming operation.

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*Evaluating Aircraft Cabin Heaters**

PRESENT-DAY extensive use of airplanes in bitter cold has made the airplane heating system of prime importance. Before the various parts of an airplane heating system can be designed, the following six properties of the airplane must be ascertained:

1. Type of airplane, that is, bomber, pursuit, transport, or other type. Since these types vary in their insulation, their heat requirements will likewise vary.
2. Speed for best climb of the airplane. This speed gives the minimum pressure supplied by the forward speed of the airplane. Duct sizes are determined from this speed.
3. Maximum cruising speed of the airplane. Additional heat will be required for heating the ventilating air, since the air volume will increase almost directly as the airplane speed.
4. Maximum diving speed. High enough pressures may be created in high-speed diving to cause failures within the duct systems. This pressure may be as large as four times the cruising-speed pressure of the airplane.
5. Maximum altitude at which the airplane will operate without a large reduction in its performance.
6. Horsepower of the engines if the exhaust gases are used as a source of heat.

The proposed temperature rise of the air must also be selected prior to making the heating-system design. This rise is made as high as the materials in contact with the heated air can safely withstand. The Douglas Aircraft Company employes a rise of 300 degrees Fahr.

Specifications in the past have required a certain temperature to be maintained within the airplane for a given outside-air temperature. It has been found that, even though the temperatures specified were maintained, the occupants of the airplane were still uncomfortable in cold weather. This phenomenon, which is a result of heat loss by radiation from the occupant's body to the cold walls of the airplane, has often been overlooked.

During a test flight it was noted that a ceiling-distribution system gave the occupant a much greater feeling of warmth than did a floor-distribution system, although the outside temperature was 20 Fahr. and the inside of the cabin was 80 Fahr. in both cases. The floor system created a velocity of air only over the occupant's feet. In contrast, the ceiling system forced warm air at 8 feet per second around the occupant's entire body. When the ceiling system was used, it was calculated that the man's skin temperature was raised from 94.3 to 96.3 degrees Fahr.

In addition to heating airplane cabins, heat is being used for preventing and removing ice from windshield surfaces, the leading edges of the wings, and empennage surfaces. Information on heat de-icing methods cannot be divulged because of military restrictions.

The three heating systems used today on Douglas airplanes are the steam, the exhaust hot-air, and the combustion types. A critical comparison of the three types has shown that the steam is heavy, unreliable in freezing temperatures, and requires frequent replacement of the boiler. On the other hand, the system is safe and with improvements in design may be of use in the future for humidifying the cabin air. Chief objection to the exhaust hot-air system is the possibility that carbon monoxide gas may enter the cabin. Yet the system is the simplest and most reliable in cold weather. The combustion heating system using a secondary mixture with fuel supplied from the engine fuel pumps is light in weight, has shown long life in a ground endurance test, and with the addition of a lightweight electric-motor-driven fan will supply heat independently of the engines while the airplane is on the ground.

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*From an A.S.M.E. paper by Wilbur W. Reaser, Douglas Aircraft Co. Inc.

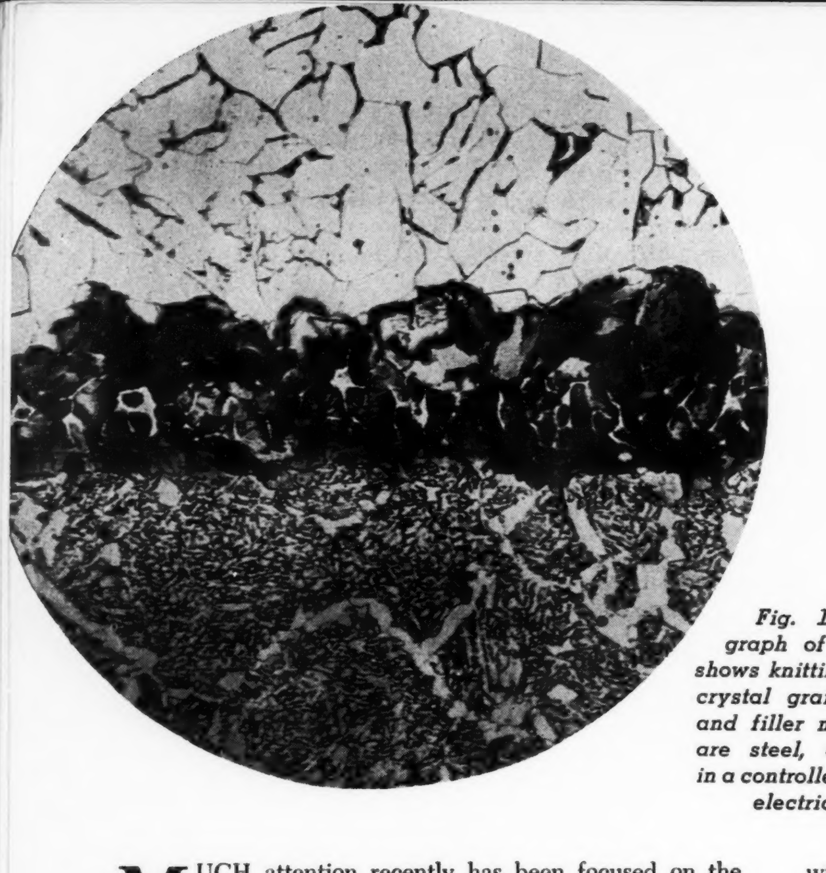


Fig. 1—Photomicrograph of brazed joint shows knitting together of crystal grains of parent and filler metals. Parts are steel, copper-brazed in a controlled-atmosphere electric furnace

How to Utilize

By Colin Carmichael

MUCH attention recently has been focused on the remarkable saving in materials and production facilities effected by using brazed assemblies in place of parts fabricated by other means. Developed under stress of war, these new processes offer the designer wider possibilities for the economical production of machine parts. •In order to assist designers in developing such parts and in specifying the appropriate process, this article presents background information on brazing materials and methods, as well as a discussion of joint design and typical applications.

Because brazing is closely allied to both soldering (being sometimes referred to as hard soldering) and welding, it is desirable to give a general definition applicable to all materials and methods. Briefly, brazing is the joining of metals, either similar or dissimilar, by means of a nonferrous filler metal melting at a temperature near or above red heat but below the melting point of either of the metals to be joined. While the exact mechanism of brazing is not fully understood, it is believed that the holding power is derived primarily from a knitting together of the crystal grains of parent and filler metals, *Fig.* 1. The importance of specifying absolute cleanliness will therefore be appreciated.

Depending on the materials used, a limited amount of alloying usually occurs. As a result it is possible to obtain joints which are stronger than the filler material alone, provided the spacing is correctly chosen, *Fig.* 2. The series of butt joints from which this figure was prepared were made from 18-8 stainless steel plates joined by a silver brazing alloy with a tensile strength of about 40,000 pounds per square inch. It will be noted that for joints less than .024-inch thick the joint strength exceeds that of the filler alone. At the optimum thickness, strength is about three times that of filler. With extremely small clearances the strength drops off somewhat, due probably to inability of the filler to flow between the surfaces at high spots where the parts were pressed together. With extremely large clearances the strength drops to that of the brazing alloy in cast form. The principles demonstrated by this example apply generally in the same manner to other materials and types of brazed joints. Reference to TABLE I will assist the designer in selecting proper clearances for other combinations of materials.

Selection of the proper brazing alloy for a particular job depends on several factors. Of these the most im-

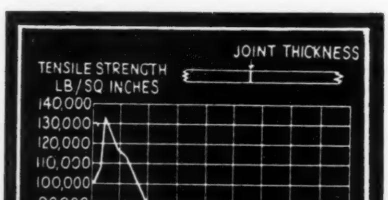


Fig. 2—Left—Due to alloying with parent metal, silver-brazed butt joints of proper thickness can show tensile strengths greatly in excess of that of the filler

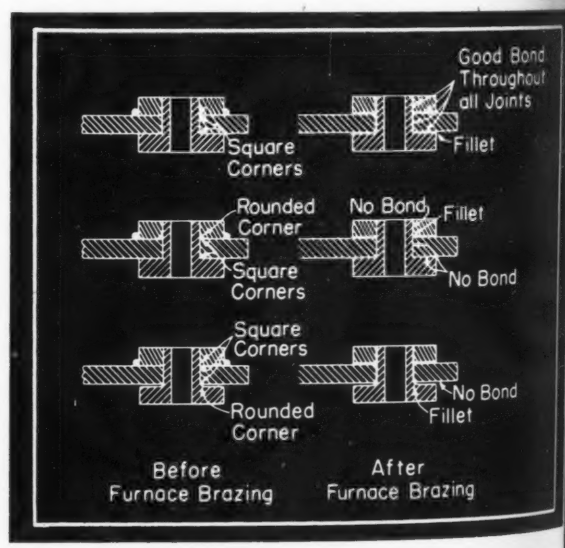


Fig. 3—Small cavities inside a brazed assembly may stop the flow of molten brazing filler, which depends on capillary action for distribution

zing in Design

Part I—Brazing Materials and Joint Design

portant are that the filler must melt and flow freely at a lower temperature than the melting point of the parent metal or metals, and the molten filler must "wet" the surface of the parent metal. When wetting occurs the filler spreads out over the surface while failure to wet causes the filler to form blobs. Use of a suitable flux overcomes difficulties due to non-wetting as a result of formation of oxide or other films.

Listed in TABLE II are some of the more commonly used brazing alloys. Of these, copper is generally con-

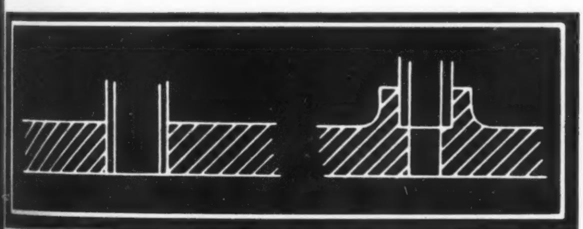


Fig. 4—Design at left requires that whole flange be heated in obtaining brazing temperature at joint with tube. Hub on right-hand design permits brazing with less expenditure of heat when using local heating methods

sidered the best due to its free flow and the strong clean joints which it produces. No flux is needed in a controlled atmosphere and, because it is a pure metal, the melting point is consistent. However, on account of the high temperature required copper is used mainly in furnace brazing, using a furnace temperature of 2000 to 2100 degrees Fahr. Joints in steel parts brazed with copper have high strength, resulting from copper penetration along the grain boundaries near the surface of the steel joints, as well as growing together of the grains, *Fig.* 1. Thus the strength of a properly designed joint is much higher than that of the copper alone.

Although copper is most frequently used in conjunction with low carbon steel in the form of stampings, screw machine parts, etc., the commoner alloy steels such as nickel, nickel chromium and molybdenum steels can be copper brazed and afterward heat treated to develop necessary strength and hardness. It is not suitable for stainless steels. Although brass was probably the first material used to braze ferrous metals, it is seldom used now because of the tendency of zinc to distill off during the heating period, as a result of which the melting point is subject to variation. However, tobin bronze which is usually applied with a welding torch is successfully used

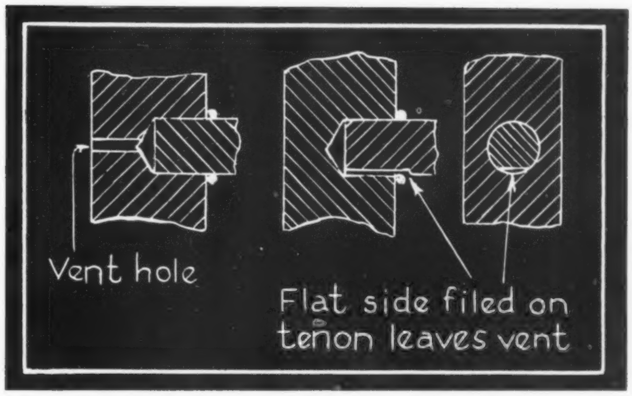


Fig. 5—Expansion of air in closed cavities may spoil joint unless vents are provided

in many applications, particularly for repair on steel, cast iron, copper alloys, etc., and where strength at high temperatures is desired.

Phos-copper is used on brass and bronze but not on ferrous materials. Tensile strength exceeding that of parent metal is claimed. Fatigue resistance also is high.

Of the silver alloys, which flow freely at low temperatures, Sil-fos gives strong durable joints on copper, brass or bronze but, like Phos-copper, is not suitable for ferrous materials due to the formation of brittle iron phosphide. Easy-flo, the lowest melting silver brazing alloy at present available, is used on both ferrous and nonferrous metals. It is particularly effective in joining dissimilar metals. For silver brazing alloys, a special flux known as Handy-flux is recommended.

Special Alloys Available

The Eutectic alloys contain materials which exhibit a particular affinity for the parent metal on which they are intended to be used. It is claimed that there is considerable diffusion of the alloy with the parent metal, analogous to welding, and that the strength and remelting points in many cases approach those of the parent metal. Of the two alloys listed in TABLE II, No. 16 is suitable for steel while No. 190 is used on aluminum alloys.

In designing a brazed joint it must be remembered that, as already indicated, the brazing alloy is usually weaker than the parent metal and that a thin film of

TABLE I

Capillary Clearances for Brazing Systems

Brazing Alloy	Base Metal	Recommended Clearance, inches
Copper	Ferrous	Press fit*, when brazing in a protective atmosphere
Copper	Stainless Steel	.0015 when brazing in a protective atmosphere
Silver alloys	Ferrous	.0015-.002
Silver alloys	Stainless Steel	.0015
Silver alloys	Copper, nickel and their alloys	.002-.003
Aluminum alloys	Aluminum alloys	Approximately .025 for long laps
60-40 Brass	Iron and Copper	.03
Tobin bronze	Ferrous	Open "V" joints

*For this purpose a good general rule to follow is to call for a maximum permissible press fit of about .001-inch per inch of diameter, allowing whatever tolerance the shop needs in the other direction.

brazing alloy is much stronger than the alloy alone. For these reasons the basic types of joints are the butt, scarf and lap types. Beads or fillets not only waste material but are weak. Butt joints generally will be weaker than the parent metal. Lap joints properly proportioned can be as strong as or stronger than the parts joined. To design a lap joint of any desired strength it is only necessary to equate the strength of the joint to strength of the part, using a safety factor and assuming that the load is equally distributed over the area:

$$fwts_t = wls_s$$
$$\text{or } l = fts_t/s_s$$

where l = length of shear surface of joint, t = thickness

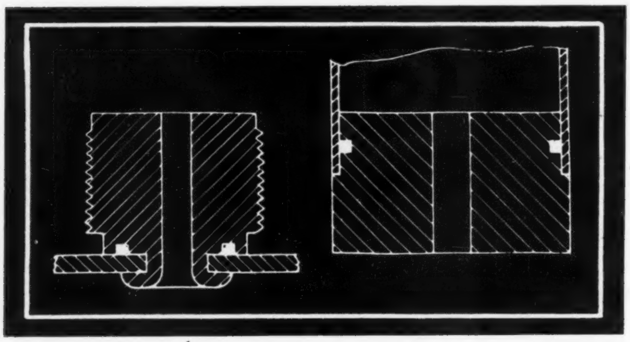
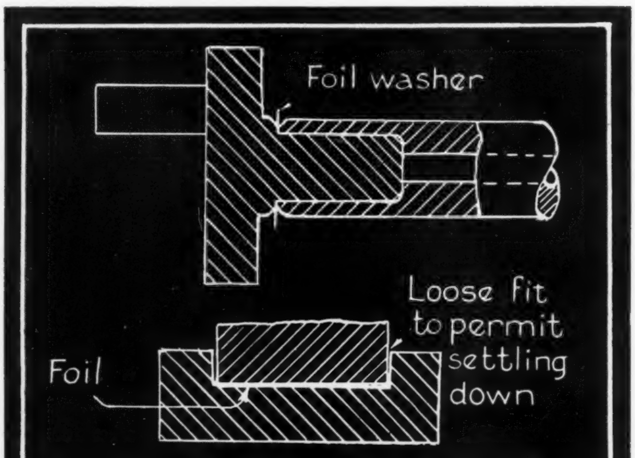


Fig. 6—Above—Ring of brazing alloy wire placed in groove inside joint obviates displacement of ring from correct position

Fig. 7—Below—Brazing alloy in the form of foil greatly facilitates the assembly of certain types of joint



of weakest member, s_t = tensile strength of weakest member, s_s = shear strength of brazing alloy, and f = factor of safety. For design values of brazing alloy strength it is well to consult the manufacturer. Joint strength varies also with parent metal and clearance.

The foregoing formula is applicable to either flat or circular sections. Substituting average values of strength into this equation, there results the simple rule that l should equal about three times the wall thickness. Where high strength alloys are to be joined, this ratio may go up to five. As a general rule it is sound practice to design all joints so that the brazing alloys are in shear.

Suggested clearances given in Table I may be used in specifying dimensions of parts to be brazed. Because of the importance of clearance already noted, particular attention should be paid to detail dimensioning. For example, the adverse effects of fillets or chamfers in the wrong place are illustrated in *Fig.* 3. Shown at upper left of the figure is an assembly prepared for furnace brazing, the ring of brazing material (copper) being preplaced around the outside of the joint. At furnace temperature the copper melts and is drawn by capillary action into all parts of the joints where the clearance is sufficiently small, as shown at upper right. However, in the center and lower sketches the presence of gaps due to rounded corners prevents flow of brazing alloy into all parts of the joint, resulting in a weak fastening.

Before the design of a brazed assembly is undertaken the heating method that is to be used should be known so that sufficiently high temperatures at the joints can be attained with a minimum amount of heat. For example if the tube and flange assembly shown at left of Fig. 4 is to be brazed with a torch, practically the entire flange would have to be heated to brazing temperature. With the modified design shown at right of the same figure only the small hub surrounding the end of the tube would have to attain the maximum temperature.

Where a brazed assembly includes a cavity, it is difficult to obtain a good uniform joint because of the pressure built up during heating as the air attempts to expand. When possible, vent holes should be provided as indicated in the design shown in *Fig.* 5.

In *Figs.* 3 and 5 the brazing alloy is shown preplaced on the outside of the joint whence it is drawn in between the surfaces by capillary action. Another method is to

Table II

Typical Brazing Filler Metals

Tradename	Composition, Ag	(per cent) Cu	Zn	Other	Softens °F	Flows °F
Copper	..	100	....	....	....	1982
Tobin bronze	..	59	40.5	.5Sn	....	1625
Phos-copper	..	92	....	7P	1317	1385
Sil-fos	15	80	....	5P	1185	1300
Easy-flo	50	15.5	16.5	18Cd	1160	1175
Castolin Eutectic No. 16	(Copper base)			....	1300*	1600*
Castolin Eutectic No. 190	(Aluminum base)			....	950*	1060*

*Binding temperature range.

preplace the brazing alloy in an internal groove, Fig. 6. This method has the advantage of obviating any displacement of the brazing alloy prior to or during heating. In addition to wire forms, brazing alloys are also supplied in the form of foil, washers, sheets and powder. Use of foil inside joints is illustrated in *Fig.* 7.

In the second and final article, brazing processes and heating methods will be discussed and the design features of several recent examples of brazing assemblies will be illustrated.

Machine Design is pleased to acknowledge the cooperation of the following companies in the preparation of this article: The Electric Furnace Co.; Eutectic Welding Alloys Co.; General Electric Co. (*Figs.* 1, 3, 4, 5, 6 and 7 and Table I); Handy & Harman (*Fig.* 2); Induction Heating Corp.; The Ohio Crankshaft Co.; Westinghouse Electric & Mfg. Co.

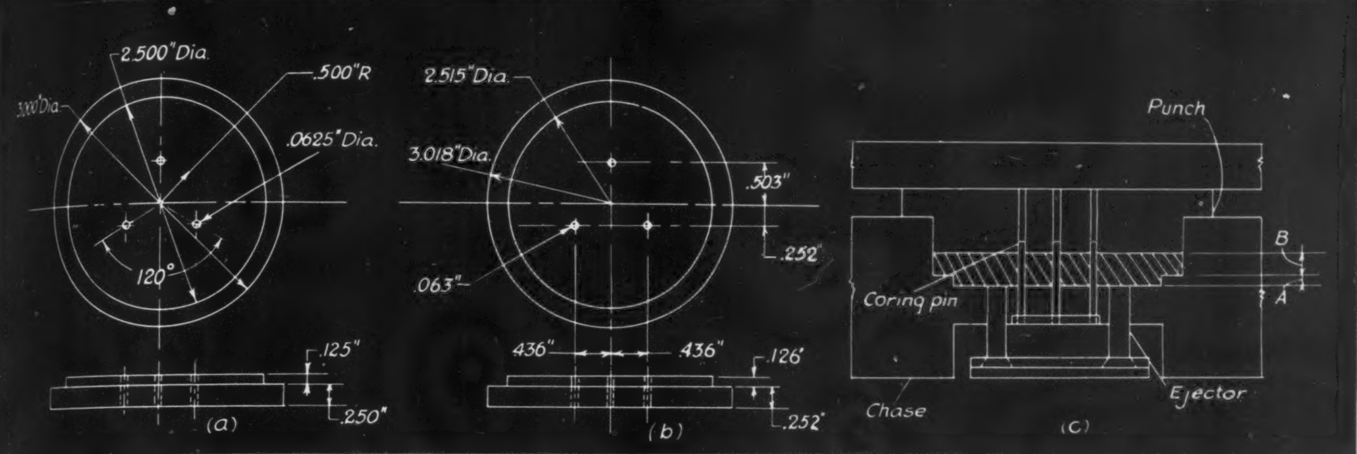


Fig. 1—Comparative dimensions of molded part and mold. Part to be molded is indicated at (a), dimensions corrected for shrinkage, at (b) a semipositive mold for producing part at (c)

Mold Principles For Plastic Parts

By John Delmonte
Technical Director,
Plastics Industries Technical Institute

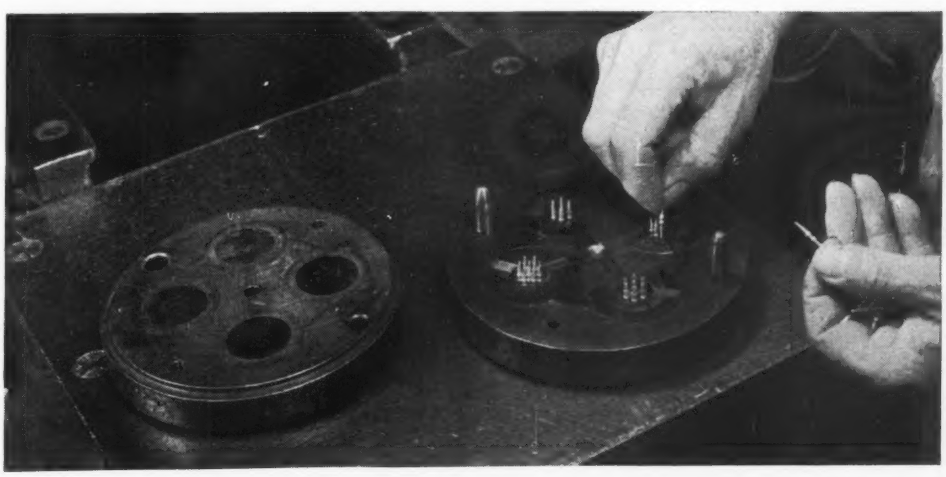
DESIGN of molded plastic parts is influenced in many ways by the character of the tools which produce them. It is a commonly accepted fact in the plastics industry that those designers who are able to visualize the molds which produce the finished pieces develop a more efficient design. Further, their full understanding of molding problems will enable them to circumvent costly design steps and utilize to fullest advantage the unusual features of the molding processes.

In the design of molded plastic parts there are several important questions which the designer should ask himself. If he can obtain a practical answer, he may expect the mold designer and the mold maker to reason likewise. Among these questions are the following:

1. If all molding materials experience mold shrinkage, what effect will that have on the shape and tolerance specified for the molded part?
2. When the piece has been molded how will it be removed from the mold? Is there sufficient draft?
3. If inserts are to be specified can they be readily held in place in the mold and is there sufficient plastic around them to avoid cracking?
4. How will the molder produce the side holes, oblique or tapered holes which have been specified?
5. What will be the relationship of the mold parting line to the molded part? Will it be in one plane, and if not, will special finishing be required?
6. Has the piece been designed so that the mold will be efficient in operation, require a minimum of repairs and adjustments, and not entail unnecessarily expensive features?

Mold Shrinkage — In dimensioning the piece to be molded the designer indicates important dimensions and

Fig. 2—Locating inserts in mold cavity of a transfer mold



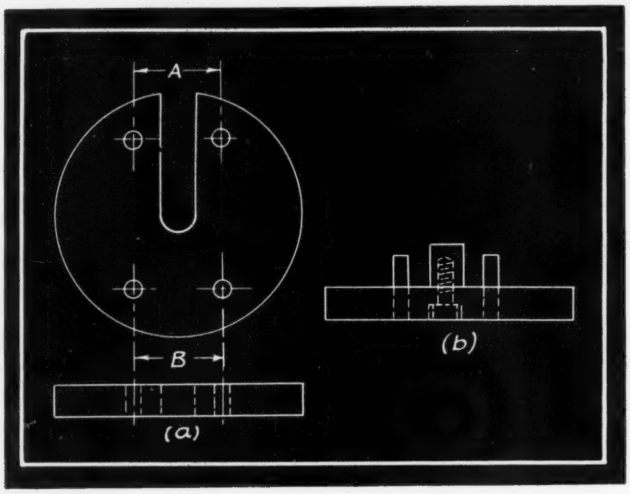


Fig. 3—Slot in molded part at (a) causes uneven shrinkage on cooling, tending to close gap A. For cooling, part is placed on shrink fixture at (b), minimizing out-of-roundness

the necessary tolerances. For the benefit of the tool room the mold designer redimensions the parts to compensate for mold shrinkage. Typical mold shrinkage values for various plastics are given in the accompanying table. To understand mold shrinkage, it should be remembered that molded parts are often removed from molds at temperatures of 300-350 degrees Fahr. when thermosetting in character. The mold maker actually makes the mold oversize to compensate for shrinkage so that tolerances will fall within those specified on the drawing, as the part cools down after ejection.

Typical Mold Shrinkage Values
Cold Mold to Cold Piece

Material	Inches per inch
Phenolic—wood flour filler	.006 — .009
Phenolic—fabric filler	.003 — .007
Phenolic—mineral filler	.002 — .004
Urea—formaldehyde	.006 — .010
Cellulose acetate	.002 — .010
Polystyrene	.001 — .003
Polymethyl methacrylate	.002 — .006

Where the part is uniform in cross section and symmetrical in shape, predetermination of mold shrinkage is not difficult and close tolerances can be held. However, as the piece grows more complicated in shape it becomes increasingly difficult to evaluate the effects of shrinkage. There is also the added problem of uneven rates of cooling which may distort the pieces after they have been ejected from hot molds.

In illustrating the problem, a part is dimensioned in *Fig. 1a*, as would the designer, whereas *Fig. 1b* shows the mold dimensions corrected for mold shrinkage. A semipositive mold appears in *Fig. 1c*, with coring pins for the three holes and ejector mechanism. This type of mold is known as semipositive because the punch has a slide fit within the chase, though a positive stop insures better dimensions parallel to the direction of molding. However, it is apparent that dimension *B* in *Fig. 1c* can not be held as accurately as *A*. When dimensions are formed between mold elements movable with respect to each other greater tolerances must be allowed. For example, in indicating tolerances, spaces between holes may be held to plus or minus .003-inch, while dimensions *B* might require at least plus or minus .005-inch. Problems like this are current in numerous small molded parts such as electrical connector plugs, shown in *Fig. 2*. In this illustration the operator is locating small pins within the mold cavity of a transfer mold.

As the design of a molded piece departs from uniform and symmetrical shapes (symmetrical in the sense that it implies uniform cooling and shrinking), the tolerances allowed must be more liberal. For example, in *Fig. 3* the tolerances of dimension *A* should be at least double those of *B*, because of the tendency of the piece to shrink out of round, with the ends of the slot moving toward one another. Of course, some correction can be made easily in this case by placing the hot-molded part on a shrink fixture as shown in *Fig. 3b*. Dimensions are thus held closer as the piece cools.

Other typical parts which may give difficulty in maintaining dimensions are contoured pieces such as fan blades where uneven shrinkage may alter the shape or pitch of the blade. Large variations in material or wall thickness may also cause excessive shrinkage. In injection molding, shrink marks appearing on the surface of the molded part are sometimes difficult to eliminate unless the mold is held warm and pressure maintained for a long time. With respect to the maximum thickness which can be safely molded, the entire design picture has

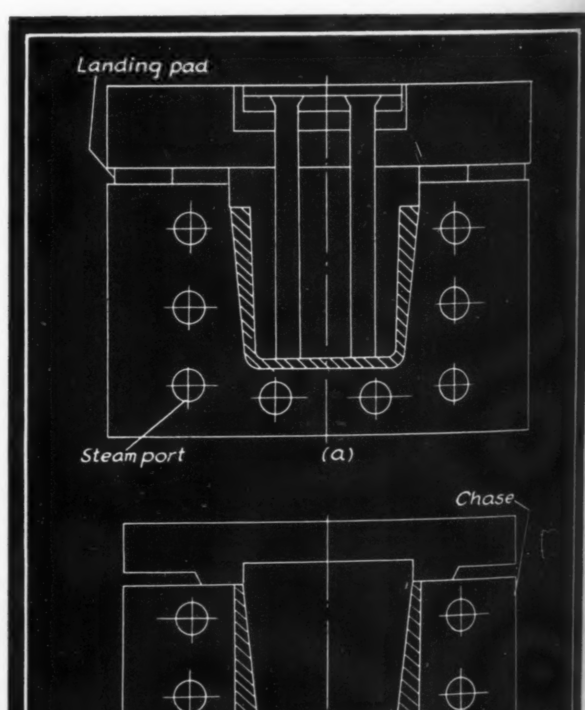


Fig. 4—Relative draft between parts of mold determine placement of ejector pins. At (a) part sticks to top half on separation of mold while the reverse is true at (b)

Fig. 5 — Right — Transfer mold for part which cannot have draft

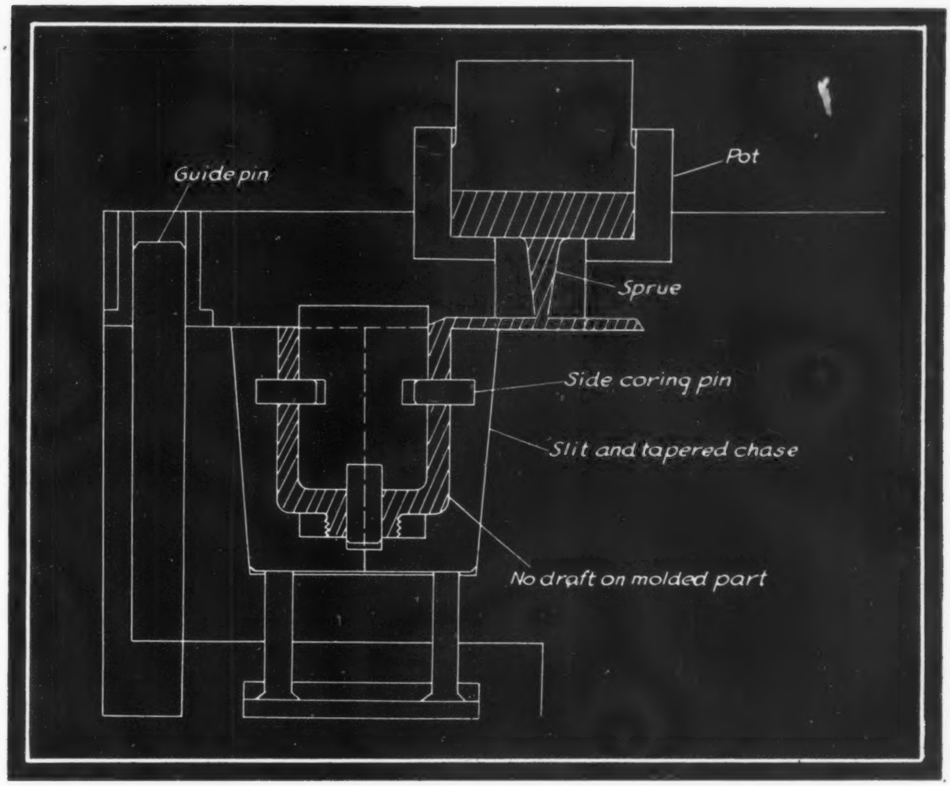
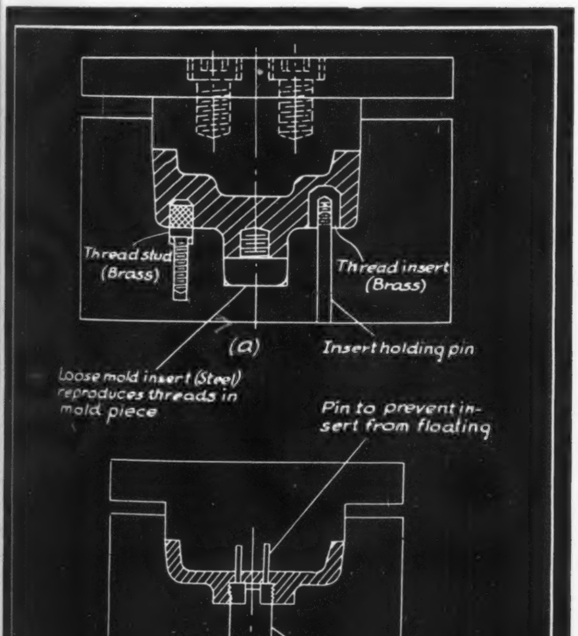


Fig. 6—Below—Methods for locating and holding inserts in place during molding



changed within recent months with the advent of radio-frequency preheating of molding materials. This new technique has permitted uniform molding of thick sections hitherto deemed impractical.

Ejection—The designer would do well to anticipate how the parts are to be ejected from the mold cavities or, if not sure, to consult with the molder who will actually perform the work. This is essential if draft or taper is to be correctly specified. No other feature of mold design affects the design of the piece to be molded as much as the technique of removing the pieces from the mold.

In some instances the mold maker has a choice of two or more methods of removing the molded part from the mold cavity, and the method employed will be governed by the design and detail dimensions of the piece. For example, in *Fig. 4a* the molded piece shrinks about the force plug and the ejection pins are located in the upper half of the mold. On the other hand, in *Fig. 4b* the draft on the inside dimensions is greatest and the piece remains in the chase when the mold halves are separated. Even the inside wall in *Fig. 4a* and the outside wall of *Fig. 4b* should have some draft to be safely ejected. Differences in mold design and ejector devices are also brought out in these figures, though flash or semipositive construction could be used in either case.

The means available to the mold maker for controlling the direction of ejection are as follows:

1. The part of the mold to be withdrawn as the molds are opened will have the greatest draft. Ejector pins or plates will enable the molder to push the pieces from the half of the mold in which they remain.
2. Slight undercuts or unpolished mold surfaces may be employed to keep the part in the desired half of the mold. Undercuts may be conveniently worked into the design or may be placed on the ends of ejector pins.
3. Draft requirements for molded parts may be as small as .005-inch per inch up to any desired taper. Large radio cabinets for example may be attractively styled with a 5-degree draft.

While examining the merits of ejector devices, the designer should recognize that best results are realized when the forces of ejection are distributed over as large

an area as possible to avoid cracking the molded parts. While there is no set rule for determining the number of ejector pins, they may be as frequent as one per square inch of area. Each ejection pin will leave its imprint on the molded part, and wherever possible the mold designer should locate these in an obscure location such as at the bottom of openings or on the surface of mold inserts.

Among other expedients available for the ejection of molded parts are stripper plates which distribute their force over a large area or sleeve-type ejectors designed for thin walled cylindrical parts.

There are numerous designs where absolutely no draft can be tolerated on certain dimensions. *Fig.* 5 illustrates a part of this character, and at the same time details of a typical transfer mold are shown. The mold is tightly closed before material is transferred from the pot through the sprue to the mold. In transfer molds and injection molds somewhat improved tolerances can be maintained because provisions for the excess molding material are confined to the sprues and runners. There are further advantages in that side coring pins and inserts are less apt to be distorted. In *Fig.* 5 the mold is split down the center. At the time of ejection, the mold halves are separated and the tapered split chase pushed from the die block and manually removed from the press. The molded piece is removed and the split mold reassembled in position.

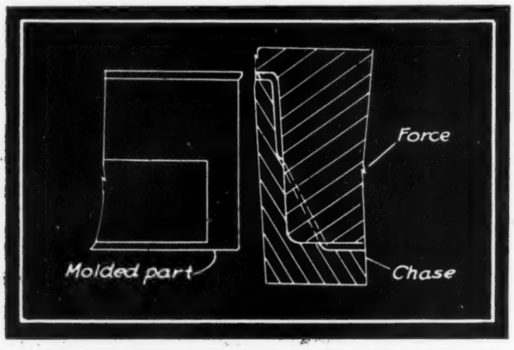


Fig. 7—Mold construction is simplified by design which allows easy removal of part

Inserts—Inclusion of metal inserts in molded parts is a problem often confronting the designer, and information on the technique of handling these by the molder, will enable him to specify their use more effectively. Of course there should be adequate provision against pulling out or turning in position after the part has been molded, though there are other important design features to consider, such as:

1. If a male or positive insert is required, a shoulder should project as in *Fig. 6a* to allow holding of the insert by the mold. Female inserts are held by insert holding pins, also illustrated in *Fig. 6a*.
2. Molding materials are mobile during the molding process and often some positive means are required to prevent the insert from "floating" away. *Fig. 6b* demonstrates how small pins in the mold will hold an insert of this type in the mold. The molded part will however, have two small holes in it where the pin positioned the insert.
3. Anything but cylindrical projections into the mold surface should be avoided.

Side Holes and Openings—Side and oblique holes will generally require side or obliquely mounted coring pins which operate independent of the rest of the mold or which will be a part of the mold cavity details. If of the latter design the mold cavity will be split to permit removal of the molded parts, as has already been shown in *Fig.* 5.

On the other hand, manually-operated or cam-operated angle pins, racks and pinions are commonly employed to produce side holes without splitting the whole mold cavity. Air-operated cylinders and solenoids have also been used to actuate such mechanisms. There are many ingenious mechanical devices which mold designers have devised to permit rapid and side coring of molded parts.

Not all side openings require split molds or special coring devices which, after all, add to the cost of the mold. For example, in *Fig.* 7 the opening in the side of the box has been so designed as to enable easy removal from the mold.

Mold Parting Lines—Mold parting lines will appear on molded parts wherever there is a division between sections of the mold cavity. A designer should visualize sufficient details of the mold construction to anticipate where this parting line will occur. No matter how much precision was used in finishing the mold, parting lines will appear. For most molded parts this is not objectionable, except where mold parting lines or flash appears on smooth well rounded surfaces because the appearance may be affected. This should suggest to the designer that mold parting lines should be minimized by ribs or recesses. Generally, it is good practice wherever possible to design so that mold parting will come all in one plane. Mold costs will be lower and finishing will be simplified greatly.

There are many factors which influence the life and wearing qualities of the mold. Molding materials themselves make a difference, inasmuch as some are much more abrasive than others. Mineral-filled materials may, for example, necessitate the replacement of coring pins every 25,000 pieces in order to keep within tolerances. Other molds, well streamlined with respect to material flow, may turn out several hundred thousand pieces without much adjustment or repair. However, every experienced molder recognizes that to skimp in the initial cost and quality of the mold would only invite costly maintenance. When large production is required, the work of the tool and die makers should be recorded in high-quality hardened steel.

Knockout pins, insert-holding pins, coring pins, etc., break or become dislocated every so often during the operation of the mold. The experienced mold maker designs his mold to facilitate their replacement with as little lost time as possible. Further, during the operation of multiple-cavity molds, the cavities are so sectionalized that if one has to be removed for repair the others can continue operation without interruption.

All molds for plastics production are expensive, ranging from a few hundred to several thousand dollars. The mold is the property of the company who pays for it and that company's designers should take pains in cooperating with the mold maker.

Suggestions Improve Designs And Reduce Costs

IN THE many suggestions for increasing production received by the War Production Drive Headquarters of WPB a large number embody ideas worthy of appraisal with respect to new designs. Most of the suggestions made are strictly of a production nature but all have greatly benefited the war program by increasing efficiency, conserving manpower and saving vital materials. A few typical suggestions that have design significance and received the recognition of WPB will be discussed briefly.

An important saving in welding time and materials was suggested by Albert Ruggieri, RCA spot-welding division. This involved the substitution of an aluminum bracket for a more costly one of stainless steel as shown in *Fig.* 1. The redesign not only released steel for other applications but so simplified fabrication and assembly that approximately 1300 man-hours have been saved in the production of 24,000 pieces. The new bracket eliminates the making of stainless steel welding rivets, drilling of holes and counterboring for the rivets, and welding of the rivets in the assembled bracket.

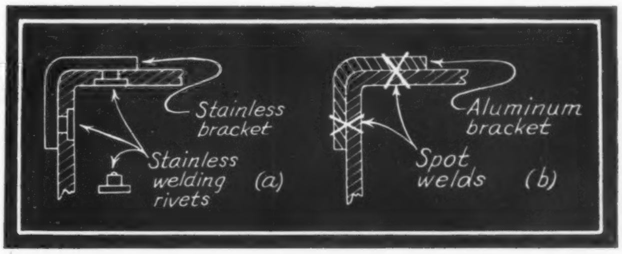


Fig. 1—Bracket at (a) was stainless steel requiring drilling, counterboring and stainless welding rivets. Redesign at (b) utilizes spot-welded aluminum bracket

A simple, ingenious device for cutting rubber tubing to accurate lengths was developed by Sam D. Carter, Northrop Aircraft Inc. Utilizing a solenoid and a pair of contacts as shown in *Fig.* 2, the cutter operates as the tubing is fed through the guide. Knife blade is attached to the plunger of the solenoid so that, when the tubing closes the contacts of the limit switch, the solenoid is energized and the knife severs the tubing. Knife is on the inside edge of a slot in the sliding plate so that the cutting action is on the pull of the solenoid,

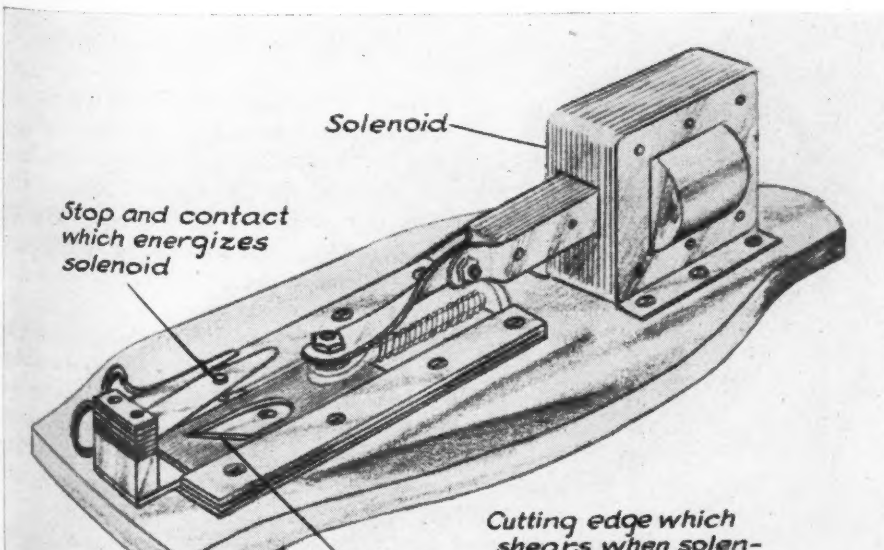


Fig. 2 — Solenoid-actuated knife for cutting rubber tubing automatically to length

Fig. 3—Right—Lever trip for 57-millimeter gun redesigned to utilize forging and coining instead of welding operations

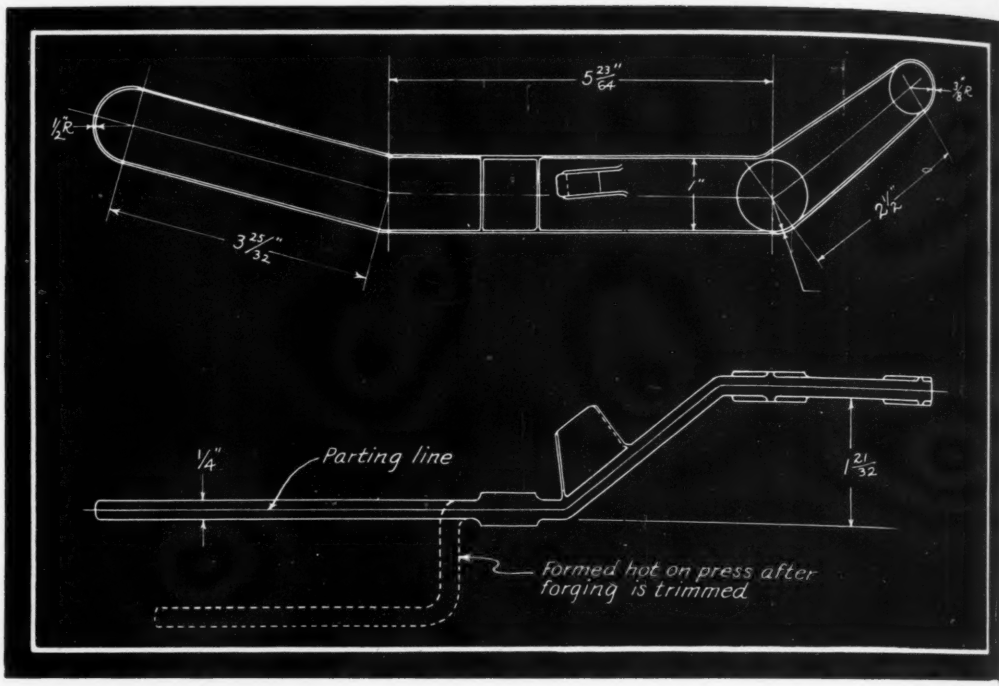
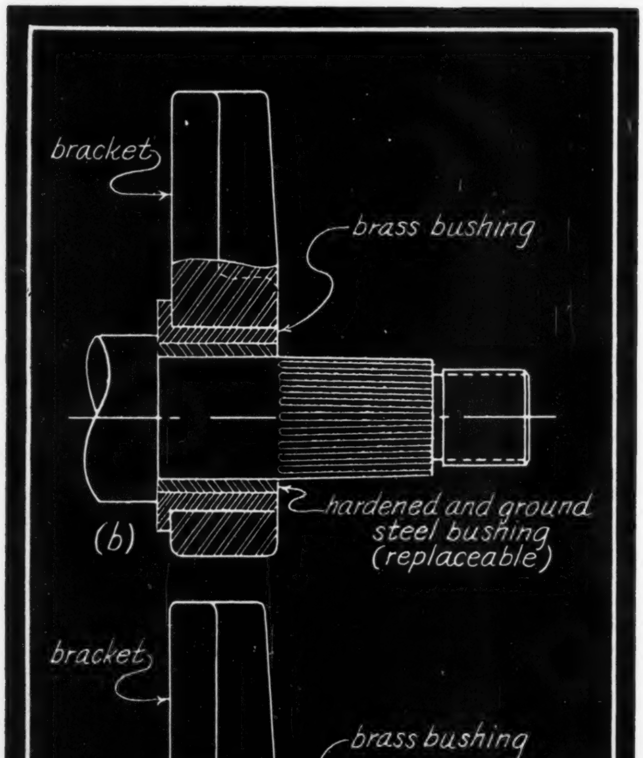


Fig. 4 — Drive knuckle for industrial truck. Original design is shown at (a) and redesign incorporating hardened bushing at (b)



a compression spring returning the plate after cutting. In operation, the unit is inverted from the position shown in the illustration so that the cut tubing falls into a box.

A lever trip for a 57-millimeter gun formerly required the welding of bosses on three places as well as the welding on of a stop and subsequent milling to size. W. Ellingboe and W. Knabe, International Harvester Co., suggested forging in one piece as shown in *Fig.* 3 to eliminate welding and milling, allowing stock for coining the boss ends. This one-piece construction instead of four welded parts produced a better quality and stronger lever. The suggestion effected a saving of 2242 production hours in welding and machining time alone. In addition much trucking and handling has been eliminated and scrap reduced.

Forging Replaces Machined Part

Another forging to replace a machined cap on a 57-millimeter gun carriage effected a materials cost reduction of $5039 and a production saving of 1918 man hours, resulting from a suggestion by Walker Eck of the same company. The cap previously was machined from 4½-inch round stock, each piece of which weighed 18 pounds. The forging is produced from 10 pounds of machine steel.

Wear on the drive knuckle for old-style two and three-ton industrial trucks necessitated too frequent servicing. Alfred Kogstad, machinist for the Crane Co., suggested inserting a hardened-steel bushing in the knuckle. Original design and redesign are illustrated in *Fig.* 4. The bushing is a drive fit and can be replaced if wear should occur.

Utilizing steel-backed bronze bushings for a gun carriage instead of phosphor bronze follows the practice adopted by the automotive industry. Use of these bushings for the carriages was suggested by Fred Scheer, International Harvester Co.

Hydraulic Lines..... Which Material, What Size?

By Richard K. Lotz

HYDRAULIC units function no better than do their interconnecting lines. To burst one of these vital veins between pump and cylinder is to invite disaster. It therefore is essential for the designer to be fully aware of the inherent merits and limitations of the various tube, pipe and hose types available.

In discussing the primary factors to be considered when selecting and utilizing hydraulic lines we are dealing, for all practical purposes, with two basic types: Rigid and flexible. Rigid lines are of course those used for interconnecting units located in fixed positions relative to each other, while the flexible type is used between units which move relative to each other.

Materials for Lines of Rigid Type

While a host of materials have at one time or another been employed in the fabrication of rigid hydraulic lines, the following serve for most applications: Copper, aluminum (usually alloy 52S-0), carbon steel (SAE 1020), chrome-moly steel (SAE X4130), bronze, monel, and 18-8 stainless steel.

Copper is highly corrosion resistant, easily bent and formed and is used most generally in low-pressure lines.

Aluminum alloy 52S-O is highly corrosion resistant, easily bent and formed and, like copper, most generally used in low-pressure lines. However, aluminum is of course considerably lighter than copper, having a density of .101-pounds per cubic inch as compared to .323-pounds per cubic inch for copper.

Carbon steel (SAE 1020), while suitable for applications involving higher pressures than either copper or aluminum, does not offer their inherent

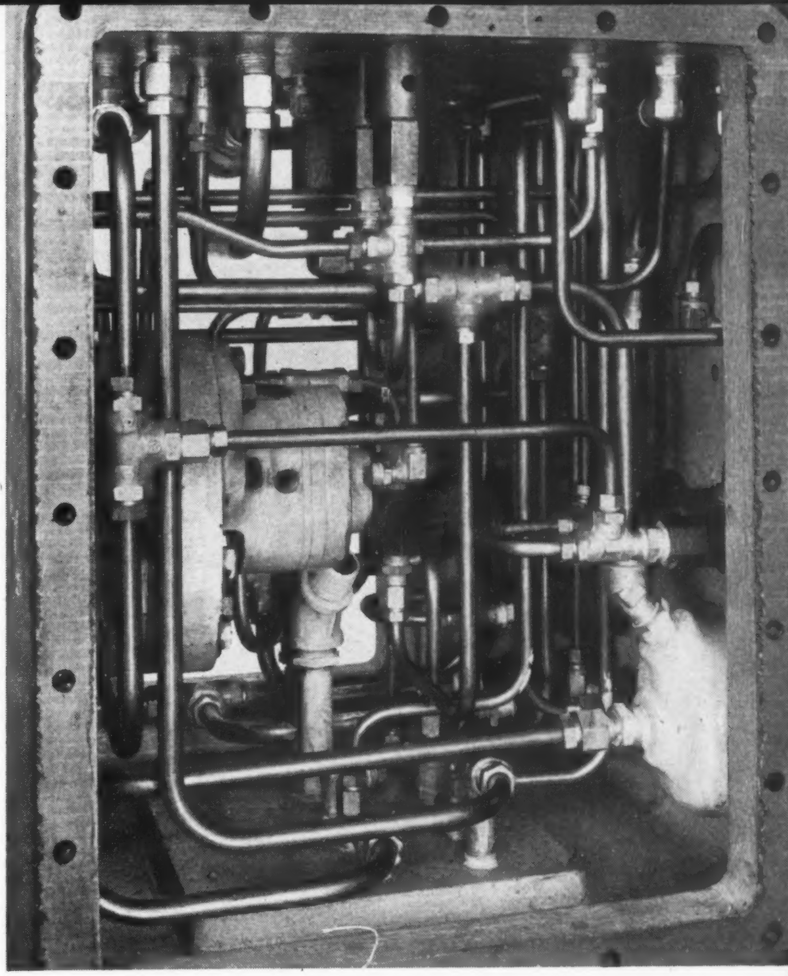
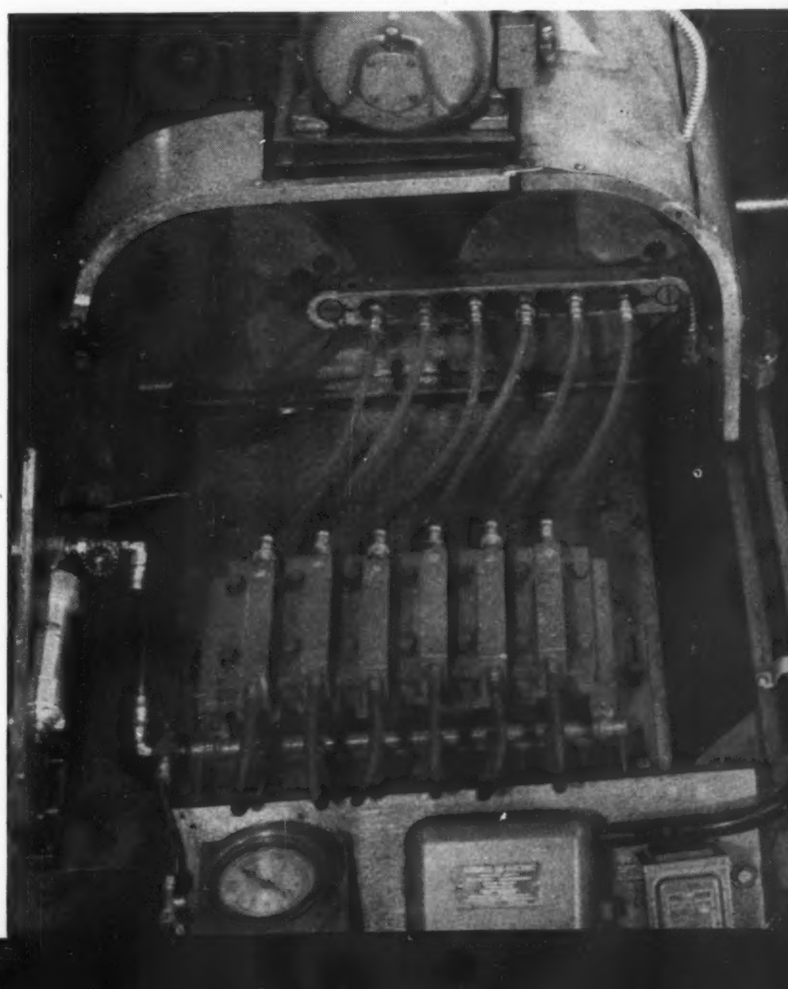
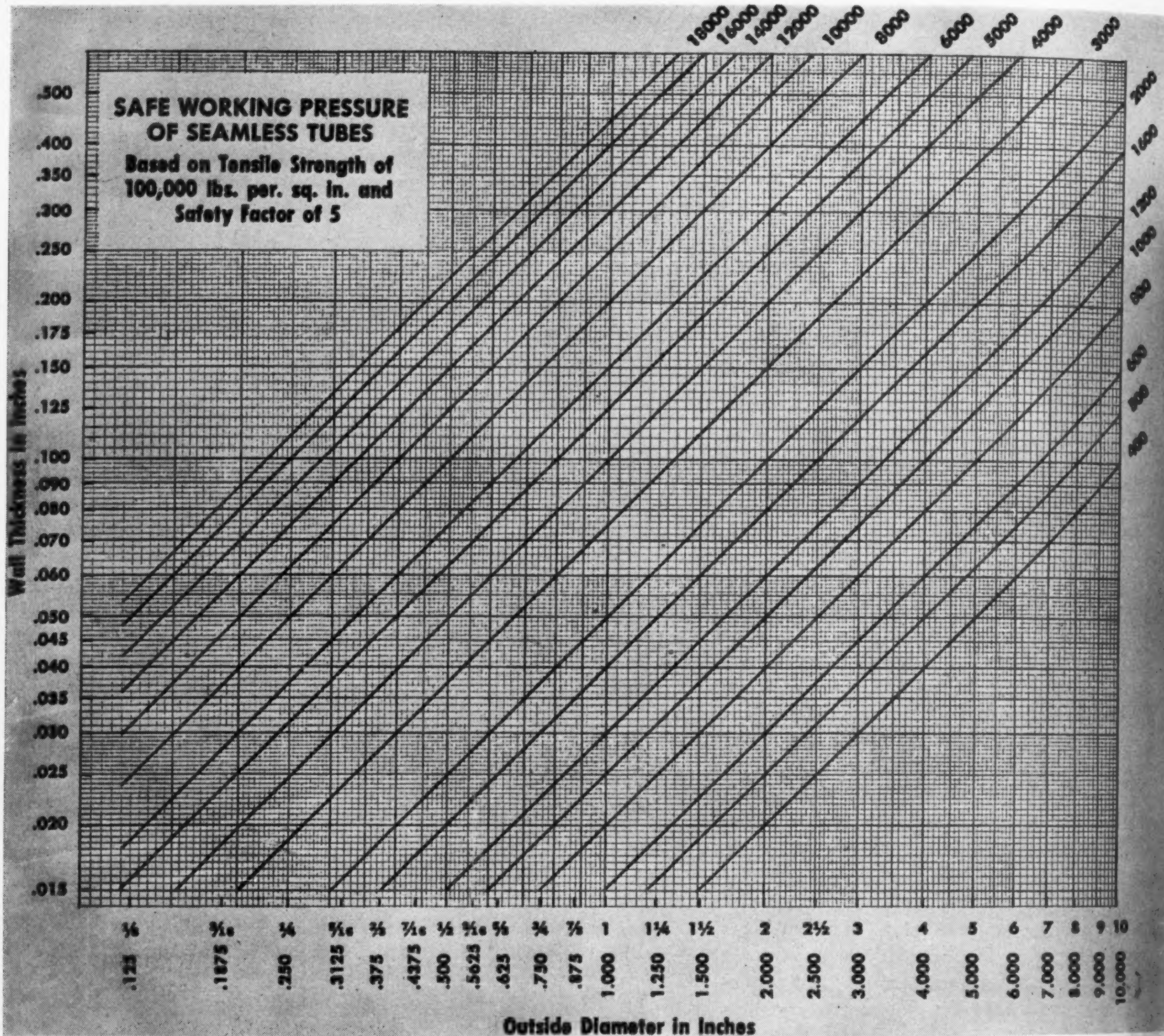


Fig. 1—Above—Seamless steel tubing is used throughout for connecting pumps, pressure control and directional control valves of machine tool hydraulic unit

Fig. 2—Below—Machine for flex-testing flexible synthetic rubber hose assemblies, showing six hoses in place ready for test





For various annealed materials, multiply pressure found on chart by K factor shown below.

Copper	$K = .3$	Carbon Steel (SAE 1020)	$K = .6$	Aluminum Alloy 52S-0	$K = .3$
Naval Brass	$K = .55$	Chrome-moly Steel (SAE X4130)	$K = .8$	Muntz Metal	$K = .48$
High Bronze	$K = .6$	Stainless Steel 18-8	$K = .8$	Monel	$K = .7$

Fig. 3—Chart may be used to ascertain tube size for any material, the tensile strength of which is known. K factor is determined by dividing tensile strength by 100,000

corrosion-resistant properties.

Chrome-moly (SAE X4130) offers more strength than any of the foregoing materials.

Bronze is of about the same strength as carbon steel SAE 1020 and has good corrosion-resistant properties. It is, however, heavier than steel.

Monel, stronger than bronze but not quite as strong as chrome-moly steel, has excellent corrosion-resistant properties.

Stainless steel 18-8 is, from the strength and corrosion-resistant standpoint, most satisfactory of all for high-pressure applications.

It should be added at this point that all these materials, when used for hydraulic tubing which must be flared at the ends, should be specified as dead-soft annealed. Harder tempers not only are likely to split at the flare but do not bend as satisfactorily.

Draw marks, scratches and burrs are to be rigorously avoided in all hydraulic tubing, as they often give rise to splitting. In addition, scale, especially on the inside of tubing, must be guarded against as it is liable to become caught in valves or other working parts and damage a precision surface or edge.

To make certain that the tubing selected will safely sustain the top pressure imposed by the hydraulic fluid, the chart in *Fig.* 3 can be used to considerable advantage for either determining tubing size when the top pressure is known, or for ascertaining what pressure can safely be sustained by a given tubing size. The chart has been plotted on the basis of a tensile strength of 100,000 pounds per square inch and a factor of safety of 5.

To demonstrate use of the chart, suppose factors such as permissible pressure drop through a line and rate of flow make it necessary to use a tube ½-inch inside diameter. Further, that the pressure to which the tube will be subjected is 1500 pounds per square inch.

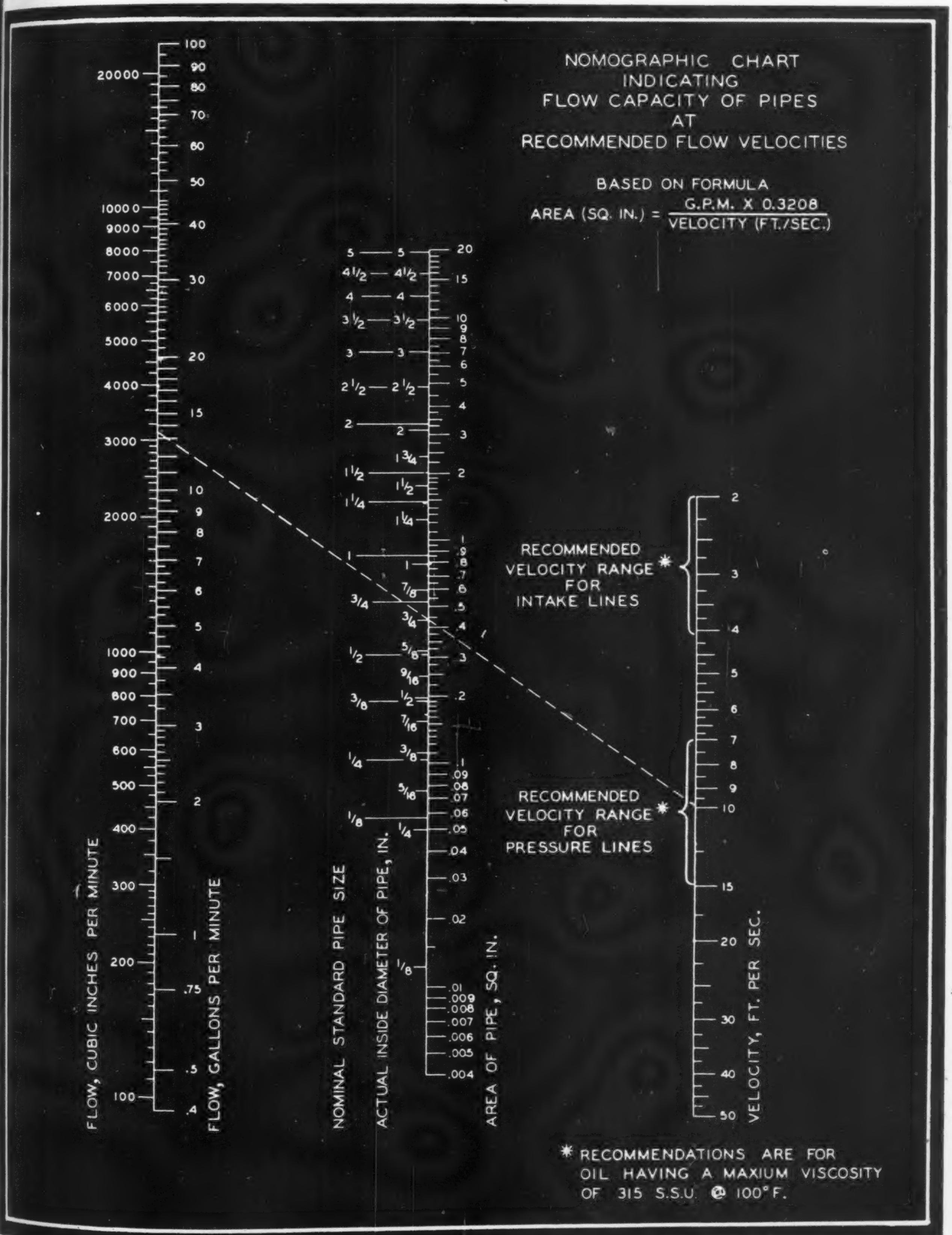
Assuming the material to be used is aluminum alloy

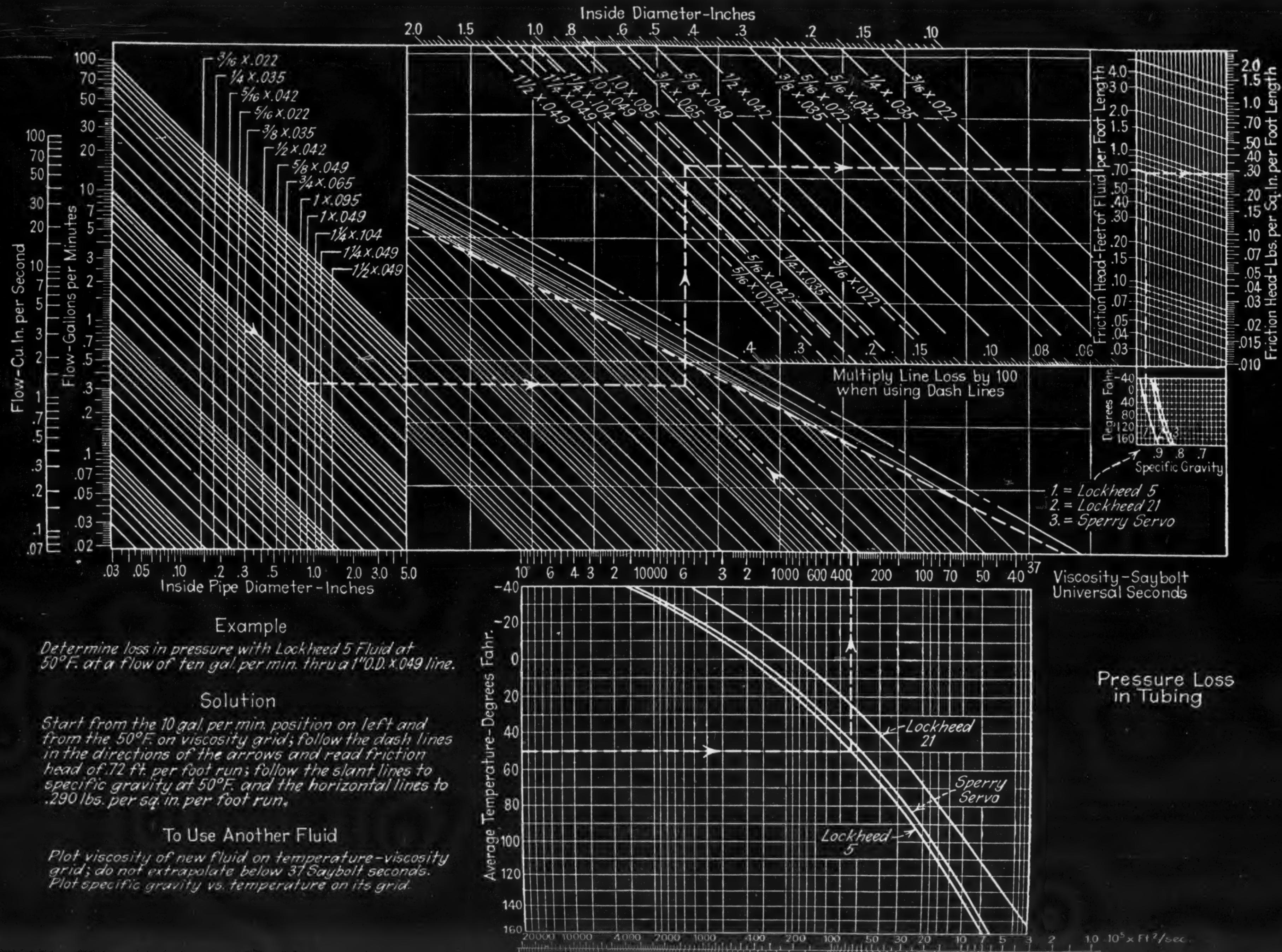
52S-O, first divide the line pressure of 1500 by the applying K factor:

$$1500/.3 = 5000 \text{ pounds per square inch}$$

Fig. 4—Below—Flow velocity chart can be used to determine rate of flow in feet per second or gallons per minute

Trace down the heavy sloping line marked 5000 to a point where a juncture of the wall thickness and outside diameter ordinates produces an inside diameter of ½-inch. In this case that point will apply to tubing ¾-inch outside diameter by ⅛-inch wall. While it is true that a tube 11/16-inch outside diameter with a wall lighter than ⅛-inch would suffice, 11/16 outside diameter tubing





Pressure Loss in Tubing

Example

Determine loss in pressure with Lockheed 5 Fluid at 50°F. at a flow of ten gal. per min. thru a 1" O.D. x .049 line.

Solution

Start from the 10 gal. per min. position on left and from the 50°F. on viscosity grid; follow the dash lines in the directions of the arrows and read friction head of .72 ft. per foot run; follow the slant lines to specific gravity at 50°F. and the horizontal lines to .290 lbs. per sq. in. per foot run.

To Use Another Fluid

Plot viscosity of new fluid on temperature-viscosity grid; do not extrapolate below 37 Saybolt seconds. Plot specific gravity vs. temperature on its grid.

Fig. 5—Opposite page—Chart for determining pressure drop in feet of fluid per foot length of line or in pounds per square inch per foot length of line

is not carried as a stock item in 52S-O.

Operating conditions other than the maximum internal pressure a line will be subjected to should be given careful consideration. Often a line is called upon to withstand mechanical abuse, excessive vibration or actual mechanical loads. To lay down hard and fast rules for determining just how much stronger than the theoretical a line must be to withstand such indeterminate loading safely would be presumptuous, since so many combinations are possible. It is wise, however, to keep these extra loadings in mind and, where they exist, select heavier tubing than ordinarily would be specified.

Laying Out a Line Path

In laying out the paths for hydraulic lines, the following points should be given due consideration:

1. Use path with least total degrees of bend. This is done to help keep flow loss at a minimum and to keep bending simple.
2. Use the path of shortest feasible length to keep weight and flow loss at a minimum.
3. Choose path with simplest bends.
4. Where possible, use path with all bends in one plane.
5. Never lay out a path without any bends at all.
6. Make sure path chosen is one along which sufficient support for line can be obtained.
7. If possible, where many lines are used together, make them identical in shape. This will cut down manufacturing cost.

Item 5 of the above may at first seem inconsistent with items 1 and 2, which might be misconstrued as indicating that a line absolutely devoid of bends would be ideal. Actually, at least one bend should be present in all lines. Without the bend, strains due to expansion and contraction of the line would have to be wholly sustained by the flared ends which are naturally weaker than the line itself. With a bend in the line, the spring action obtained readily absorbs all minute lineal displacements.

In regard to item 6, the importance of securely supporting the lines throughout their entire length cannot be overstressed. Lacking such support, vibration of the lines causes failure at the joints through fatigue. In addition, small hydraulic units are sometimes actually supported by the lines, so it naturally follows that the lines must in turn be firmly anchored.

Pressure Drop and Head Loss

For all practical purposes these two terms are synonymous, their difference being in the units with which they are expressed. Calculating every factor influencing pressure losses due to flow in lines is a lengthy and tedious task. To eliminate the need for such calculations, the charts shown in *Figs.* 4 and 5 are presented. These charts apply to flexible as well as rigid lines.

Given the S.S.U. (Saybolt Seconds Universal) viscosity of the hydraulic fluid, the temperature at which it will operate, inside diameter of the pipe, and rate of flow in gallons per minute, it is a simple matter to trace off the velocity in feet per second, the pressure drop (friction head) in feet of fluid per foot length or in pounds per square inch per foot of length.

Cursory examination of the chart in *Fig.* 4 will show that it can be used either to determine velocity of flow in feet per second when the inside diameter and flow in gallons per minute are given, or for determining the flow in gallons per minute when the velocity in feet per second is known.

To determine pressure drop by use of the chart in *Fig* 5*, the following procedure is recommended: Locate point on the left-hand scale which conforms to rate of flow in gallons per minute involved in the problem. Trace down on line sloping toward right until vertical line of pipe inside diameter is reached. From this intersection point, trace horizontally to the right to applying S.S.U. line (sloping up toward left from the base line). At this point, trace up vertically to intersect inside diameter line (sloping down toward right from top line of chart) and from the point thus located, trace horizontally to the right until the friction head (head loss) scale is reached. The evaluating units on this scale are "feet of fluid per foot length of pipe".

For pressure drop in pounds per square inch per foot

(*Continued on Page* 216)

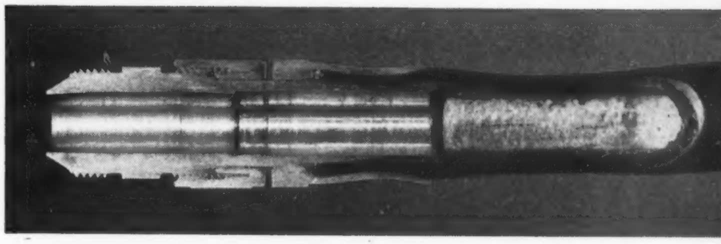


Fig. 6—Above—Low pressure flexible synthetic rubber hose utilizes single cotton braid reinforcement

Fig. 7—Below—Two-braid cotton reinforcement is used in this medium pressure flexible synthetic rubber hose

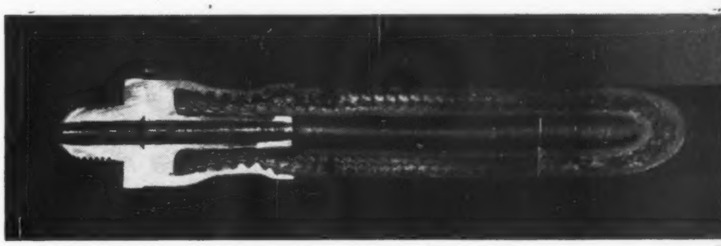


Fig. 8—Below—A medium pressure flexible synthetic rubber hose employing three-braid cotton reinforcement

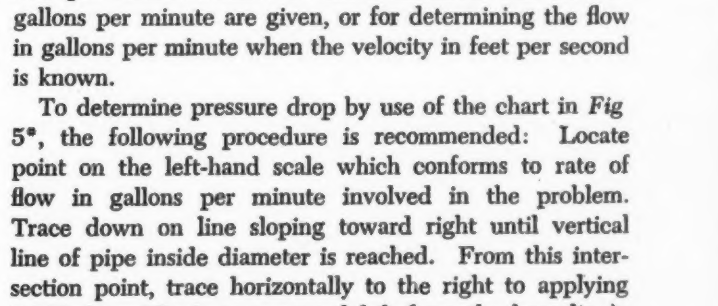


*Chart reproduced from Harold W. Adams' book *Aircraft Hydraulics*, by permission of the publisher, McGraw-Hill Book Co. Inc.

Applying Standard Gearmoto

By C. B. Connell
Westinghouse Electric & Mfg. Co.

WHEN gearmotors first gained acceptance in industry about 1930, each individual manufacturer's method of application seemed to serve the purpose well until about 1938. Then it became apparent that, since gearmotors were being accepted into so many varied industries and types of applications, uniform methods of classification and uniform output speeds should be established. Of course, any step toward standardization is recognized as a step in progress and the American Gear Manufacturers association entered into the work enthusiastically. The result was not only standard application methods and output speeds, but also a standard method for design and rating, which is now recognized throughout industry.

A.G.M.A. practice divides the main application group into three classes, defined in Table I. Contained in the practice is a list of certain typical and more common gear-

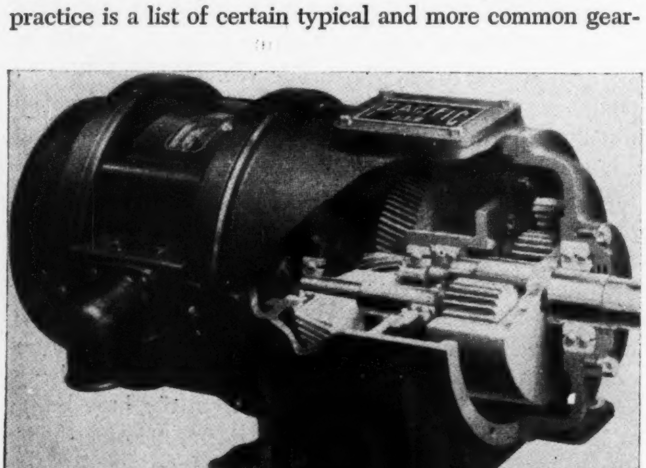
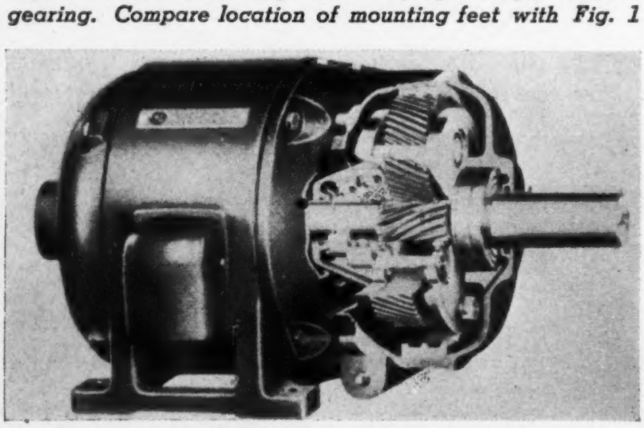


Fig. 1—This double-reduction unit employs dual intermediate high-speed gears and low-speed pinions

Fig. 2—Below—Planetary unit employs single helical gearing. Compare location of mounting feet with Fig. 1



motor applications, identified according to the nature of the load and duty cycle into the three commonly recognized classifications, some of which are shown in Table II. Although no attempt has been made to include all possible applications of gearmotors, a sufficient number and variety have been covered to serve as a guide for other selections. Gearmotor standard practice also contains a list of standardized output speeds shown in Table III as adopted by the joint committee of the American Gear Manufacturers association and the National Electric Manufacturers association.

Gearmotor standards include limitations for allowable shaft stresses, which take into consideration an accepted

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BECAUSE of the unusual problems encountered in specifying and as a result of the increasing application of gearmotors in all types of machinery, the American Gear Manufacturers' association recently established standards covering the design and application of such motors. In this article, which is an abstract of a committee report presented at the recent semiannual meeting of the association, the new standards are discussed and information given that will assist the designer in selecting the best gearmotor for a particular job

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maximum value for stress concentration effects for bending and torsion due to fillets, keyways, etc., as gearing shafts are subjected to variations in load and reversals of stress. When stress concentration factors exceed 1.75 for high-speed and 1.5 for intermediate and low-speed shafts, it is necessary to compute the combined stress by the generally accepted maximum shear theory, applying concentration factors as specified in the practice. The maximum stresses must not exceed the endurance limit of the material, which is considered to be 25 × BHN.

Foundation and bearing bolt stresses must not exceed certain allowable values in tension based on carrying maximum overhung loads at rated horsepower for the various classes of service.

Allowable overhung loads must be based on the weakest of shafts, bearings and bolting, using the stress limits set forth in the standards. The load limits should be based on the load being at the approximate center of the output shaft extension, with the unit securely bolted to a rigid and properly leveled supporting base. Extraneous shaft loads must be multiplied by the following factors in order to obtain the effective pull: Chain—1; Pinion—1¼; V-Belt—1½; Flat Belt—2½.

Gearmotor manufacturers specify the allowable over-

Machines

hung load capacity of each respective rating. For applications in which the required overhung load is in excess of that allowed by the unit size but which would otherwise suit the application, the unit may sometimes be altered or modified. Otherwise it will be necessary to select a gearmotor to suit the overhung load rather than the horsepower and output speed rating.

Most gearmotor manufacturers employ gear cases made from high-grade cast iron or semi-steel, usually machined in special fixtures to maintain close tolerances in center distance and alignment to insure interchangeability in gearing and quietness of operation. Gearing must be, in general, heat treated for necessary strength and wear life to form a unit as compact as possible. Spur and helical gearing are used in the concentric and parallel shaft design gearmotors. *Figs.* 1 and 2 illustrate two different types of gearing and gear arrangements as used in gearmotors.

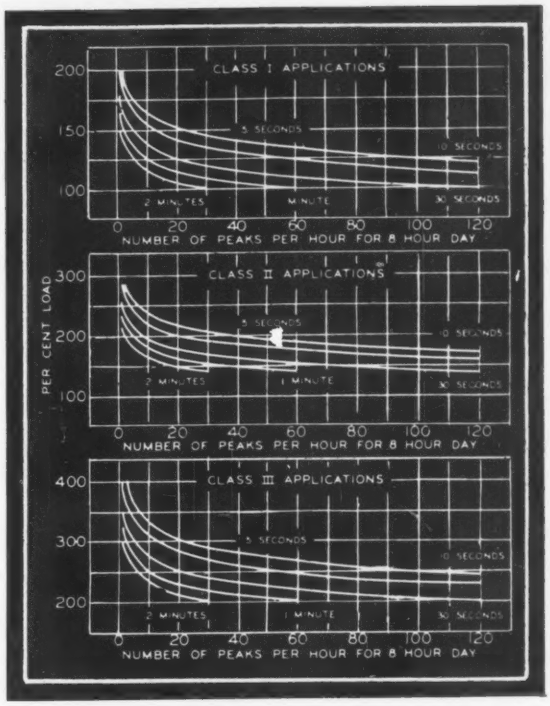


Fig. 3—Right—Curves show allowable peak loading for gearmotor applications, for peaks of indicated duration

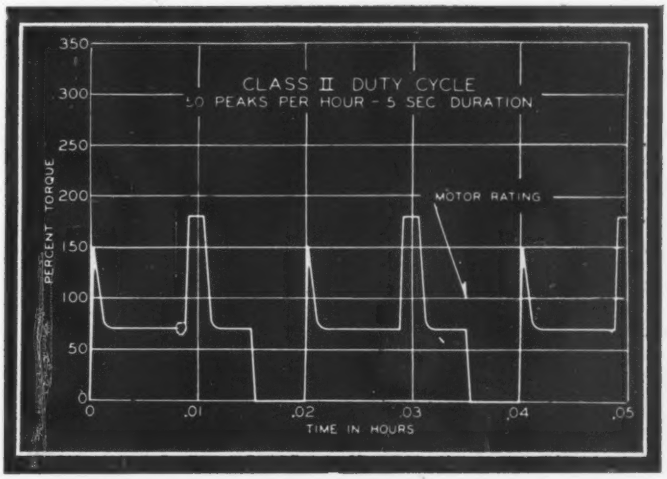


Fig. 4—Below—Illustrates a typical duty cycle which would require use of a Class II gear-motor

Curves Aid Gearmotor Selection

To assist both the customer and the manufacturer in determining the proper class of gearmotor, when high torque or intermittent rated motors are involved, there has been established a set of curves, *Fig.* 3. These curves indicate the number of peak loads of a certain intensity and duration that are allowable per hour for an 8-hour day. In order to apply these curves correctly it is necessary to determine, either from similar applications, present installations, or past experience, the duty cycle of the application. The duty cycle should indicate the highest torque value, as well as its duration and frequency, that the gear will be required to transmit. Where peak torques are of greater intensity and frequency than are covered by the range of the curves, the gear should be selected on the basis of the peak torques being the normal rating.

TABLE I

Classification of Gearmotors

Class	Type of Load
I	For steady loads not exceeding normal rating of motor and 8 hours a day service. Moderate shock loads where service is intermittent.
II	For steady loads not exceeding normal rating of motor and 24 hours a day. Moderate shock loads for 8 hours a day.
III	Moderate shock loads for 24 hours a day. Heavy shock loads for 8 hours a day.

Certain applications not listed can be classed as more or less customers' responsibility. For example, a company manufacturing a standard line of reciprocating compressors must either select its own gearmotor classification, or furnish the gearmotor manufacturer with a torque-effort diagram which includes the flywheel effect. However, in selecting a gearmotor for reciprocating compressors or similar equipment (due to the frequency of the peak loads in this type of equipment), the peak loads imposed on the gearing should be considered as a normal load and the gear classification selected accordingly. By referring to the definition for the A.G.M.A. classes in TABLE I, it is found that Class I permits steady loads for 8 hours per day and Class II permits steady loads for 24 hours per day. By using the peak loads as the normal and selecting the gear as Class I for 8 hours per day and Class II for 24 hours per day, builders of reciprocating compressors and similar equipment can make a satisfactory gear selection.

However, when gearmotors are selected by the user on the basis of the peak torque being the normal rating, it should be specifically stated when placing an order with the manufacturer. The gearmotor manufacturer is obligated to stamp the A.G.M.A. classification on the data

Table II
Typical Gearmotor Applications

Application	8 to 10-hr. service	24-hr. service
Agitators		
Pure liquid	I	I
Variable density	II	II
Blowers		
Centrifugal	I	II
Lobe	II	II
Compressors		
Centrifugal	I	II
Lobe	II	II
Reciprocating—Multi-Cylinder		
Adequately flywheeled (within 3% cyclic variation)	II	III
Reciprocating—Single cylinder	Refer to Factory	
Cranes & Hoists		
Main hoists—medium duty	II	II
Main hoists—heavy duty	III	III
Skip hoists	II	II
Travel motion	II	II
Trolley motion	II	II
Food industry		
Beet slicers	II	II
Cereal cookers	I	II
Dough mixers	II	II
Meat grinders	II	II
Laundry washers	II	II
Machine tools		
Punch press (gear-connected to load) and shears	III	III
Notching press (belt driven)	I	II
Plate planers	III	III
Other machine tools—main drives	II	II
Auxiliary drives (feed-traverse, etc.)	I	II

Application	8 to 10-hr. service	24-hr. service
Rubber industry		
Mixers	III	III
Calenders	II	III
Mills	III	III
Sheeters	III	III
Tire-building machines	II	II
Tire and tube press openers	I	I
Tubers or strainers	II	II
Pumps		
Centrifugal—with surge tanks or equivalent	I	II
Centrifugal—without surge tanks	II	II
Gear and rotary—constant-density fluid	I	II
Gear and rotary—variable-density fluid	II	II
Proportioning pumps	II	III
Reciprocating—with open discharge	I	II
Reciprocating—multi-cylinder, double-acting	II	II
Reciprocating—single-cylinder	Refer to Factory	
Textile industry		
Batchers	II	II
Calenders	II	II
Card machines	II	III
Dry cams	II	II
Dyeing machinery	II	II
Looms	Refer to Factory	
Mangles	II	II
Nappers	II	II
Soapers	II	II
Spinners	II	II
Tenter frames	II	II

plate and if the application is in excess of Class III, then the data plate should be suitably stamped to indicate a special classification.

A gearmotor is essentially a slow-speed motor yet is entirely different from a motor. A general-purpose induction-type motor, for instance, is designed to deliver its rated horsepower continuously within the guaranteed temperature rise. This same motor is capable of delivering intermittently certain overloads of a duration and frequency that do not cause the temperature rise to exceed

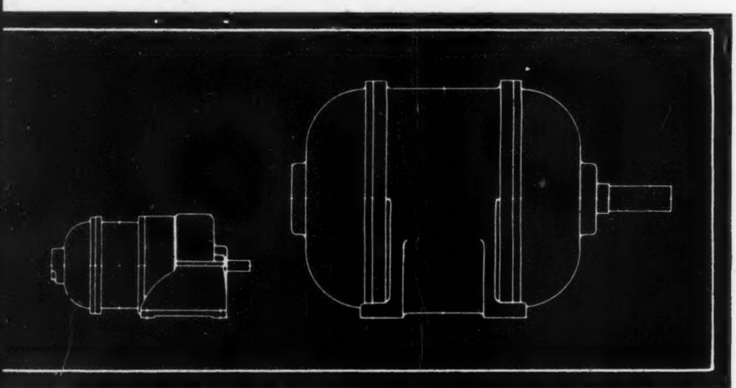


Fig. 5—Five-horsepower 290-rpm motor at right weighs 1910 pounds compared with 285 pounds for the Class I gearmotor at left, which is rated five horsepower at 230-rpm output speed. Overall heights are 29⅝ and 13¼ inches

safe limits. If the motor is inadequate for the application it will overheat, thereby giving an outward indication of distress. A gearmotor, consisting of a motor and its reduction gear, must operate as a unit. The reduction gear, being between the motor and the driven equipment, cannot divorce itself from the inherent characteristics of either the motor or driven equipment.

If the gear is overloaded the component parts may be subjected to stresses in excess of their designed capacity. Shafts, bearings, or gears may be overstressed depending on the member that has the least capacity at the particular output speed involved. Failure of overloaded gear parts may be gradual or may occur in a short period of time, depending entirely upon the relationship of the stress imposed and the endurance limit of the material

Table III
Standard Gearmotor Output Speeds

Rpm	Rpm	Rpm	Rpm	Rpm
1430	420	125	37	11.0
1170	350	100	30	9.0
950	280	84	25	7.5
780	230	68	20	6.0
640	190	56	16.5	5.0
520	155	45	13.5	4.0

used in the parts. In order to prevent an overloaded condition, the gear must be selected with, or protected by, an application factor and this is accomplished by the proper A.G.M.A. classification.

For applications where the equipment goes through a definite duty cycle involving varying torques which produce a fluctuating load, it is first necessary to select the proper motor rating for the load and duty cycle. After the proper motor has been determined, the duty cycle should be analyzed for peak torque intensity, duration and frequency to determine the proper classification for the gear.

Fig. 3, previously discussed, shows the permissible peak torque intensity, duration and frequency per hour for an eight hour day. *Fig.* 4 illustrates a typical duty cycle for which the proper gear has been selected. The figure shows the type of duty cycle which would require a Class II gear. As shown, the duty cycle calls for 50 complete cycles per hour for an 8-hour day. The gearmotor starts, runs at 70 per cent of normal motor rating for three-fourths of the cycle, with the exception of a 5-

(*Continued on Page* 236)

MACHINE *Editorial* DESIGN

Economic Aspects of Postwar Period Cannot Be Minimized

SCARCELY a meeting of any kind—engineering, marketing or management—is held these days that does not include a paper, a session or a whole day's discussions on the subject of postwar activities.

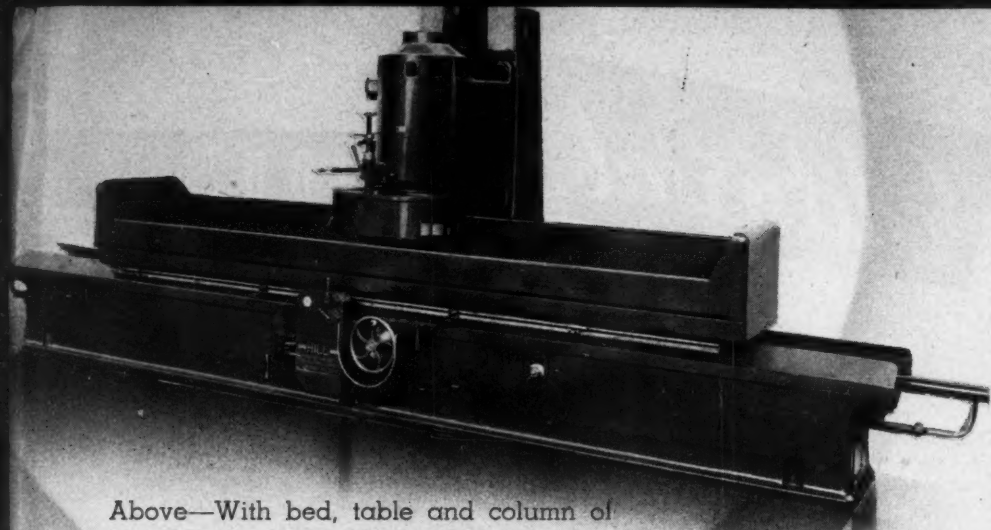
Many of the earlier meetings on this subject "glamorized" far too much, particularly from the standpoint of design, the period immediately following the war. Fanciful stories were told of the skies swarming with new types of planes, of highways streaming with ultramodern high-speed automobiles, and of machines of practically every conceivable type incorporating wonderful electronic devices. It is unquestionable that we later will have radically different planes and cars, and that electronics will have wide application as a result of what has been learned through wartime usage—but that these things will come to pass quickly after the end of the war can be put down as so much wishful thinking.

One prime reason for this—especially in the consumer field—is that in order to get a prompt start on re-manufacture of machines and on re-employment, it is essential that technically sound models, based largely on prewar designs, be developed. Another reason is that the market already is here for all kinds of consumer equipment on which production has been held up due to the war. And a third reason, perhaps the most vital of all, is that money will not be as free-flowing as has been imagined because of high taxes, lack of money on the part of the ten million or so men returning from the services, and financial drain in general.

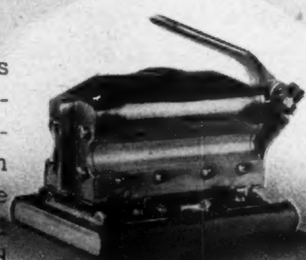
As far as concerns other types of machines coming within the classification of capital goods—metalworking machines being a good example—the picture is different. Such machines have been refined and improved throughout the war, and it obviously will be essential that designers put forward every effort to develop radically new designs to render obsolete the machines already in use. That this is being done to meet war requirements and will continue to be done to meet market conditions after the war, is an acknowledged fact.

There will be innovations in design of all classes of machines—lots of them. But design executives will do well to keep these factors closely in mind: Market requirements, need for rapid re-employment, and the country's strained economic position.

L. E. Jermy

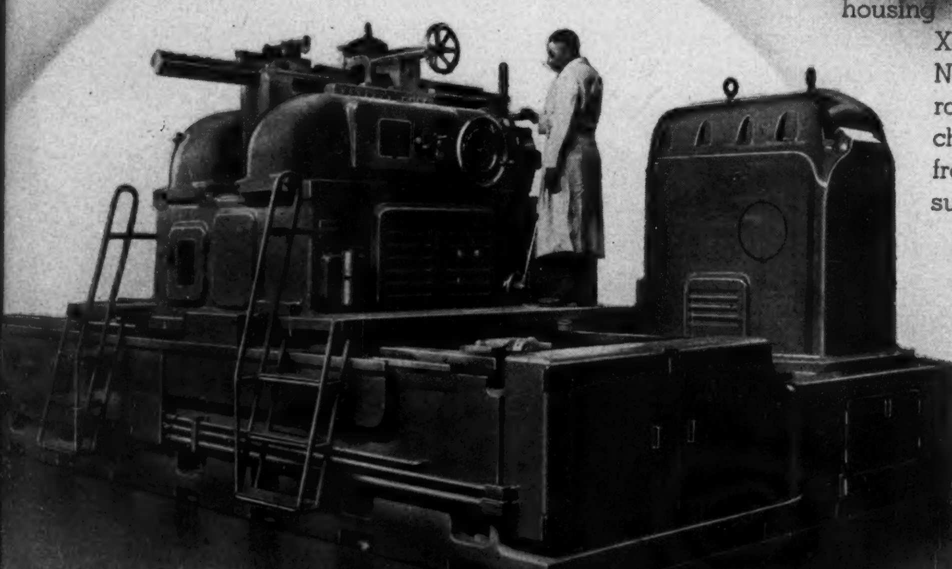


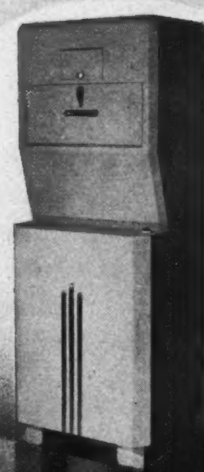
Above—With bed, table and column of heavily ribbed special normalized cast iron, maximum rigidity insures permanence of accuracy of Hill Acme's vertical spindle hydraulic surface grinder. Dynamically balanced, its hardened alloy steel spindle is direct driven by enclosed fan-cooled motor



Right — Vibration is eliminated by oppositely reciprocating pad-driving pistons in Sundstrand Machine Tool's pneumatic hand sander. Housing, end plate and palm-grip control are cast aluminum. Slides are carburize-hardened 1020 steel, valve is hardened steel forging

Below—Motor driven through flexible coupling, work gear of National Broach and Machine Co. gear shaver is mounted on journal bearings supported by adjustable pedestals. Headstock and saddle assemblies which support cutter and checking heads are self-contained units having individual motor drives. Pressure lubrication is used throughout except for saddle ways which have automatic gravity feed





Above—Electrically welded sheet steel housing with baked enamel finish is X-ray proofed by lead lining on North American Philips Searchray, an X-ray inspection machine. Operator is protected from electric shock by air insulation and complete grounding of machine

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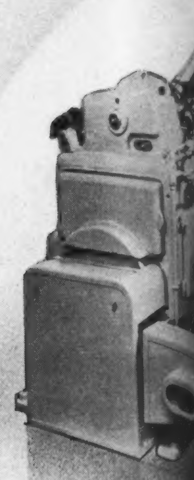

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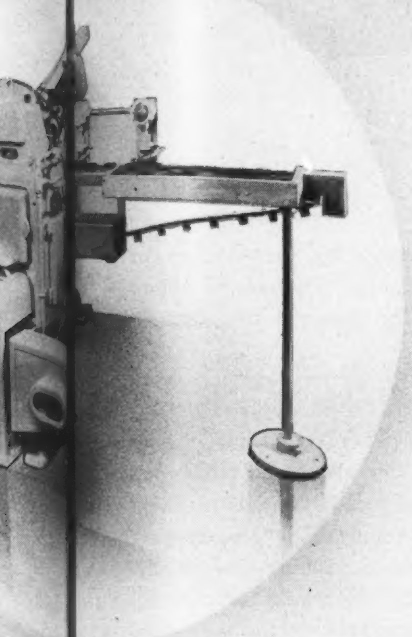
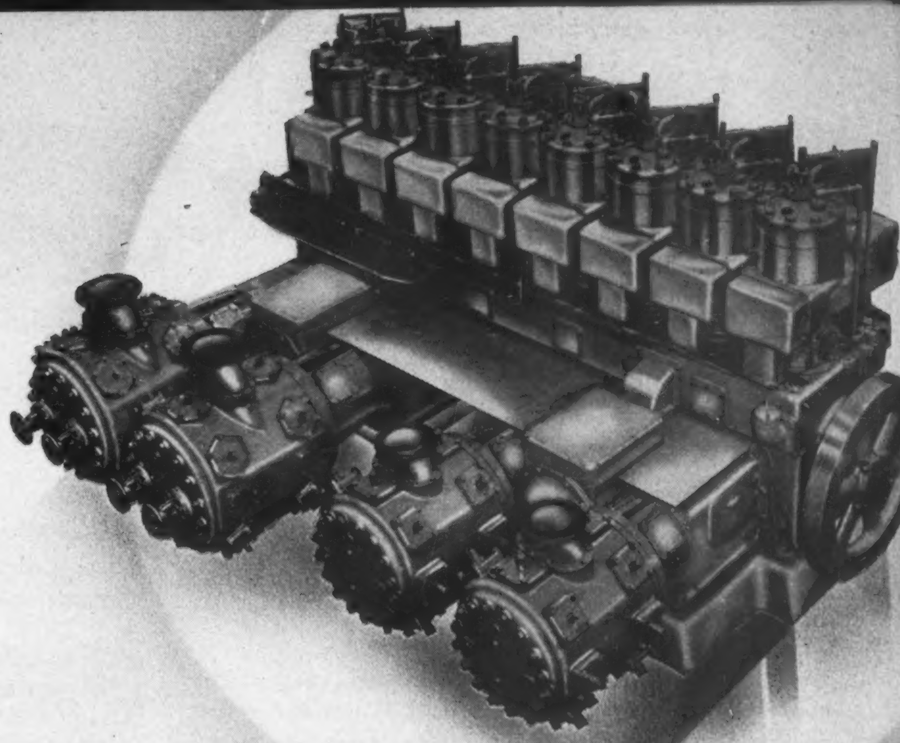




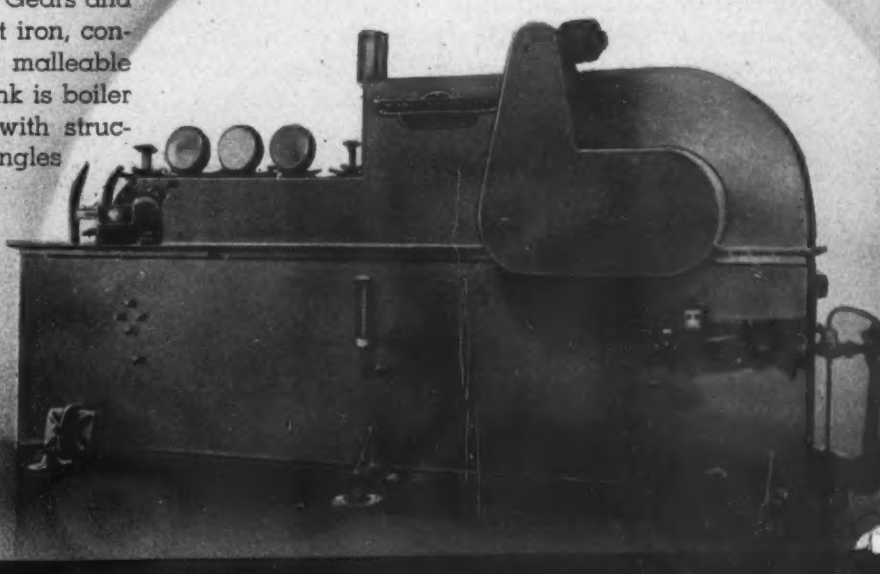
Above—Low bearing pressures are achieved by employing individual connecting rods to compressor and power pistons of eight-cylinder supercharged gas-engine-driven compressor made by Clark Bros. High velocity spiral water jackets cool all power cylinders and heads. Crankshaft is single piece steel forging

ac es Behind
t Guns

(For ise listings, see page 252)

Left—Coolant is circulated by vane type pump through black iron pipe on Hammond abrasive belt grinder. Protection from grit, dust and sludge is provided for shaft and shaft ways by neoprene bellows-type covers. Abrasive belt is maintained at constant tension by automatic take-up mechanism

Right—Worm type motor reducer drives through roller chain and spur gear train to conveyor of Barry-Wehmiller antitank mine coating machine. Chain drive employs slip clutch for conveyor overload prevention. Gears and sprockets are cast iron, conveyor chain is malleable iron and main tank is boiler plate reinforced with structural steel angles



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Design Roundup

Future of the Helicopter

IN THE AIRCRAFT FIELD, nothing has caught the popular fancy like the helicopter and its postwar possibilities. Yet clear thinking aircraft engineers are practically unanimous in the belief that many design improvements will have to be made in the helicopter before its airworthiness to the general public can be demonstrated. Lou Leavitt, rotary wing consultant to two major manufacturers, says the present concept of the helicopter is no more the ultimate answer than was the Wright brothers first airplane the answer to modern air transportation. And A. E. Raymond, vice president of engineering for Douglas Aircraft, echoes a similar sentiment in stating, "Helicopters today are in the stage of development that our present planes passed through about 1910." Two of the disadvantages of the helicopter (and there are others) mentioned by Mr. Raymond are its fundamental incapability of being streamlined, and its inherently small size. The current fanfare and drum-beating for the helicopter might well wreck its future, just as similar publicity wrecked the future of the autogyro.

Replaces Tungsten Steel

ONE OF THE LATEST developments which has come as a result of the shortage of critical alloying elements is an ordnance part which has been designed to use high-tungsten steel for its hardness qualities. One company has succeeded in making this part of plain carbon steel, and through special heat-treating technique has obtained a hardness sufficient to pass the tests to which the tungsten steel was subjected. This part has been accepted as a suitable alternate by Army Ordnance, and is now in production. Savings—considerable volume of difficult-to-get tungsten and even more of money.

Engine Is Reversible

ALLISON ENGINE, having gone through 19 model changes in 2½ years, now is designed so that it may be converted from right-hand to left-hand drive as required for some planes by simply turning the crankshaft and camshaft end to end and making a few other minor changes. Incidentally, prestressing by shotblasting or peening connecting rods and crankshafts has aided Allison designers in meeting demands for higher horsepowers.

Dimensionally Accurate Castings

ENGINEERS who fret about poor finishes on castings and the inability of foundrymen to produce castings to precision dimensions may be surprised if some of the present work on "investment" casting proves adaptable industrially. This casting method, long practiced by jewelers and dental manufacturers, involves an entirely new technique in mold making which yields ideal surfaces requiring no finishing, and castings which are dimensionally accurate. Now principally used in connection with casting precious metals, the process or some variation may find its way into the carbon and alloy-steel fields.

NE Steels Perform Well

IN THE APPLICATION of National Emergency steels to machine parts, a keener understanding of their functions is proving helpful to design engineers. Experience is demonstrating the ability of NE steels to do well nearly all jobs within the range of their hardenability. Use of these steels for large gears, for instance, or for any other parts where there is considerable plate thickness, has never been advised by leading exponents of NE steels. Usually they would not harden deeply enough. On the other hand, where the NE steels are properly applied, as in the case of wristpins, they do their job as well as the higher alloy steels. Employment of the new steels, most of which are of the nickel-chromium-molybdenum types, is gaining as further experience reveals their most suitable applications.

Predetermined Hardness

ONE of the tractor companies is installing induction heating equipment which will heat treat steel bars continuously at a cost of $15 a ton compared with mill extras of $30. Some steel companies are interested in the development and materials for specifically predetermined and uniform hardness may be available soon in quantities of only four or five bars if necessary.

Conversion Units in Lubrication Analysis

By R. C. Binder
Purdue University

IN LUBRICATION calculations, questions frequently arise as to the units and dimensions of physical factors. Confusion and errors may result in attempts to correlate various design data on friction. Purpose of this data sheet is to discuss the units of the important factors involved, in an attempt to expedite a clearer understanding of friction and other calculations

FOR cylindrical bearings it is common practice to correlate the friction coefficient f as a function of the parameter zN/p, where z is the absolute or dynamic viscosity of the lubricant, N is the shaft or journal speed in revolutions per unit time, and p is the bearing pressure. The ratio zN/p can be made dimensionless by employing any set of consistent units. In some machine design text and reference works z is expressed in centipoises, N in revolutions per minute, and p in pounds per square inch. Although this combination involves a hybrid set of units, the resulting parameter is a useful design tool.

Some factors are simple, the friction coefficient f, for example, being a dimensionless ratio of two forces. Viscosity usually is the most troublesome factor, but units and conversions can be reasoned out by referring back to fundamental definitions.

Using F as the dimensional symbol for force, L for length, and T for time, then area has the dimensions of L^2 (length squared), stress or pressure has the dimensions FL^{-2} (force per unit area) and velocity has the dimensions LT^{-1} (length divided by time).

Viscosity Units

Absolute or dynamic viscosity is defined by the relation:

$$\text{Dynamic viscosity} = \frac{\text{Shear stress}}{\text{Rate of shear strain}}$$

Shear strain or angular strain is a dimensionless ratio (length divided by length), therefore rate of shear strain has the dimension T^{-1} (velocity divided by length). Thus the dimensions of dynamic viscosity are $FL^{-2}/T^{-1} = FTL^{-2}$.

In the American system, dynamic viscosity may be expressed in pound-second per square foot, or in pound-second per square inch. One pound-second per square inch is called a "reyn", but no acceptable name has been proposed for the pound-second per square foot. In the metric system the unit of force is the dyne and the unit of length is the centimeter, hence dynamic viscosity may be expressed in dyne-second per square centimeter. One dyne-second per square centimeter is called a "poise" after Poiseuille, an early French investigator of viscous flow. The centipoise, or .01-poise, is a common unit approximately equal to the dynamic viscosity of water at 20 degrees Cent. (68 degrees Fahr.).

Conversions between the American and metric systems can be worked out by noting that

$$1 \text{ inch} = 2.54 \text{ centimeters, and}$$
$$1 \text{ dyne} = 2.248\text{x}10^{-6} \text{ pounds.}$$

An example of such a conversion follows:

$$1 \text{ poise} = 1\frac{\text{dyne second}}{\text{centimeter}^2} \times 2.248 \times 10^{-6}\frac{\text{pound}}{\text{dyne}}$$
$$\times 2.54^2\frac{\text{centimeter}^2}{\text{inch}^2} \times 12^2\frac{\text{inch}^2}{\text{foot}^2}$$
$$= 2.089 \times 10^{-3}\frac{\text{pound second}}{\text{foot}^2}$$

Dynamic viscosity conversion units are summarized in TABLE I.

Units of zN/p Ratio

Using a consistent set of units involving pound, second, and foot, the units of zN/p are:

$$\frac{\left(\frac{\text{pound second}}{\text{foot}^2}\right)\left(\frac{1}{\text{second}}\right)}{\frac{\text{pound}}{\text{foot}^2}} = \frac{\text{pound second foot}^2}{\text{foot}^2 \text{ pound second}}$$

which is a dimensionless ratio involving no conversion

factor. The same result is found if a consistent set of units involving dyne, second, and centimeter is employed.

As already indicated, z often is expressed in centipoises, N in revolutions per minute, and p in pounds per square inch, a hybrid set of units. Here let the numerical value of zN/p in this set of units be denoted by the letter B. The problem is to determine the factor K by which B must be multiplied in order to obtain a dimensionless zN/p ratio which does not contain any conversion factors. This problem could be worked out by various methods, one of which is outlined in the following.

Dynamic viscosity in centipoises can be converted to pound-second per foot squared by multiplying by $.02089 \times 10^{-3}$. Revolutions per minute can be changed to revolutions per second, and pounds per square inch can be changed to pounds per square foot. Thus

$$BK = .02089 \times 10^{-3}\,\frac{\text{pound second}}{\text{foot}^2} \times \frac{1}{60}\,\frac{\text{minute}}{\text{second}} \times \frac{1}{12^2}\,\frac{\text{foot}^2}{\text{inch}^2} \times B$$

$$K = 2.418 \times 10^{-9}$$

If the numerical value B is multiplied by 2.418×10^{-9}, the resulting zN/p ratio is dimensionless, and applicable to any set of consistent units.

Values of dynamic viscosity are frequently worked out from measurements taken with a Saybolt or other type viscometer. The viscometer is an instrument which has been arbitrarily standardized, giving a reading which is correlated empirically with a factor termed the "kinematic viscosity". An empirical correlation between Saybolt seconds universal and kinematic viscosity, based on experimental results, is included in the *A.S.T.M. Standards,* 1939, Part III, Page 215. It is of importance to note that the so-called "Saybolt viscosity" for example, is not the same as absolute, dynamic, or kinematic viscosity, being expressed in seconds, which is different from any of the units of viscosity.

Kinematic Viscosity and Density

Kinematic viscosity is defined by the relation:

$$\text{Kinematic viscosity} = \frac{\text{Dynamic viscosity}}{\text{Density}}$$

density being defined as mass per unit volume. From the fundamental relation (force) = (mass) × (acceleration), mass has the dimensions of FT^2L^{-1}. Thus density has the dimensions of FT^2L^{-4}. Then the dimensions of kinematic viscosity are $FTL^{-2}/FT^2L^{-4} = L^2T^{-1}$. Kinematic viscosity can be expressed in such units as feet-squared per second, or centimeters-squared per second. One centimeter-squared per second is called a "stoke" after G. Stokes, an English scientist. For example, if an oil has a kinematic viscosity of one stoke, then the kinematic viscosity is:

$$1\text{ stoke} = 1\,\frac{\text{centimeter}^2}{\text{second}} \times \frac{1}{2.54^2}\,\frac{\text{inch}^2}{\text{centimeter}^2} \times \frac{1}{12^2}\,\frac{\text{foot}^2}{\text{inch}^2}$$

$$\doteq .001076\,\frac{\text{foot}^2}{\text{second}}$$

In the metric system density is expressed in grams per cubic centimeter. Density is sometimes confused with specific gravity, which is a dimensionless ratio. Specific gravity of a particular substance is defined as the ratio of its density to the density of some standard substance. In the metric system the standard is usually taken as water at a temperature at which the density is close to one gram per cubic centimeter. Thus, for practical purposes, in this system density and specific gravity are numerically equal, but not dimensionally equal. Thus, an oil having a density of .85 grams per cubic centimeter has a specific gravity of .85. If the kinematic viscosity of an oil is .52 centimeter-squared per second and the density is .85 grams per cubic centimeter, the dynamic viscosity of this oil is .52 × .85 = .442 poise or 44.2 centipoise.

TABLE I

Viscosity Conversion Constants

One poise	= 100 centipoise
	= 14.51×10^{-6} pound-second-inch^{-2}
	= 2.089×10^{-3} pound-second-foot^{-2}
One centipoise	= $.1451 \times 10^{-6}$ pound-second-inch^{-2}
	= $.02089 \times 10^{-3}$ pound-second-foot^{-2}
	= .01 poise
One pound-second-inch^{-2} (reyn)	= 144 pound-second-foot^{-2}
	= 68.95×10^{3} poise
	= 6.895×10^{6} centipoise
One pound-second-foot^{-2}	= 6.944×10^{3} pound-second-inch^{-2}
	= 478.7 poise
	= 47.87×10^{3} centipoise

In the American system the pound is usually taken as a unit of force and the "slug" as a unit of mass. Probably the word slug came from the term sluggishness or inertia. For specific gravity calculations, the standard is usually taken as water at a temperature at which the weight (force) per unit volume is 62.4 pounds per cubic foot. If a body weighs 1 pound, then the mass of that body is 1/32.2 slug. If the specific gravity of an oil is .85, this oil weighs .85 × 62.4 or 53 pounds per cubic foot. This oil has a density of (.85 × 62.4)/32.2 or approximately 1.65 slugs per cubic foot. It is to be noted that 1 pound equals 1 slug-foot per second-squared.

As an example, consider an oil which has a kinematic viscosity of .00056 foot-squared per second and a specific gravity of .85. Then

$$\text{Dynamic viscosity} = \text{Kinematic viscosity} \times \text{density}$$

$$= .00056\,\frac{\text{foot}^2}{\text{second}} \times \frac{.85 \times 62.4}{32.2}\,\frac{\text{pound second}^2}{\text{foot}^4}$$

$$= .000923\,\frac{\text{pound second}}{\text{foot}^2}$$

Materials Work Sheet

Filing Number 17.00

LAMINATED PHENOLIC PLASTICS

NEMA GRADES X, XX and XXX

(Paper Base)

AVAILABLE IN:

(Grade X) Plate, rolled and molded tubing
(Grade XX) Plate, rods, rolled and molded tubing
(Grade XXX) Plate, rod and molded tubing

PHYSICAL AND ELECTRICAL PROPERTIES

TENSILE STRENGTH*

(min.—psi.)

	Grades X	XX	XXX
Plate	9,000	6,000	5,000
Tubing, rolled	7,500	7,000	
Tubing, molded	9,000	7,500	
Rod	....	11,700†	10,600†

COMPRESSIVE STRENGTH*

(min.—psi.)

	Grades X	XX	XXX
Plate, loaded flatwise	31,000	25,000	25,000
Plate, loaded edgewise	17,000	15,000	15,000
Tubing, rolled, axial load	10,000	12,000	
Tubing, molded, axial load	15,000	15,000	.....
Rod, axial load	.....	20,000†	24,000†

FLEXURAL STRENGTH*

(min.—psi.)

	Grades X	XX	XXX
Plate, loaded flatwise	16,000	15,000	12,000
Plate, loaded edgewise	16,000	12,000	12,000
Rod	.....	22,000†	20,000†

CHARPY IMPACT STRENGTH*

(unnotched, min., ft. lb. per in.)

	Grades X	XX	XXX
Plate, loaded flatwise 90 deg. to fiber warp	7.0	3.6	3.8
Plate, loaded flatwise parallel to fiber warp	3.8	2.8	2.8
Plate, loaded edgewise 90 deg. to fiber warp	5.3	3.6	3.2
Plate, loaded edgewise parallel to fiber warp	3.5	2.8	2.7

*Values apply to plates up to 1-inch thick. Above 1 and to 2 inches thick, minimum values are 10% lower.
†Values based on tests conducted in laboratories of The Formica Insulation Co. Other values conform to 1939 NEMA standards.

SHEAR STRENGTH†

(psi)

	Grades X	XX	XXX
Plate, loaded flatwise	11,000	11,500	10,000
Plate, loaded edgewise	10,000	10,500	8,000
Rod	.....	10,000	10,000

MODULUS OF ELASTICITY

(average—times 10^5, psi)

	Grades X	XX	XXX
Plate, loaded edgewise 90 deg. to fiber warp	11.7	9.4	11.5†
Plate, loaded edgewise parallel to fiber warp	17.1	10.4	13.0†

AVERAGE HARDNESS

(Rockwell M, 1/4 ball, 100 Kg)

	Grades X	XX	XXX
Flatwise	114	112	111
Edgewise	108	106	105

OTHER PROPERTIES

	Grades X	XX	XXX
Weight (lb. per cu. in.)	.0487	.0487	.0487
Specific Gravity	1.35	1.35	1.35
Max. Water Absorption 24 hrs. at 25 deg.C ± 2 deg. C. Specimen 3 by 1 by: 1/16 thk.	6%	2%	1.2%
1/8 thk.	3.3%	1.3%	.85%
1/2 thk.	1.1%	.55%	.45%

MACHINE DESIGN is pleased to acknowledge the collaboration of the following in this presentation: The Formica Insulation Co.; National Electrical Manufacturers Association; Synthane Corp.; Westinghouse Electric & Mfg. Co.

Materials Work Sheet

OTHER PROPERTIES *(cont'd.)*

	Grades: X	XX	XXX
Max. Water Absorption at Saturation (3 by 1 by 1/16 thk)	15%	8%	6%
Min. Dielectric Strength (volts per mil) in oil at 25 deg. C., stock 1/16 thk.			
Short time tests, flatwise	500	500	500
edgewise ...	60	60	60
Step by step tests, flatwise ..	300	300	300
edgewise	45	45	45
Max. Power Factor at 10^6 cycles	.07	.045	.035
Max. Dielectric Constant at 10^6 cycles	6.5	5.5	5.2
Max. Loss Factor at 10^6 cycles ..	.45	.25	.18
Average Coef. of Thermal Expansion parallel to laminations (inches/inch/deg. C.)	.000024†	.0000256†	.000028†

APPLICATION

These materials are used extensively where a combination of light weight, strength and good electrical insulation is required. Suitable for parts such as instrument panels, switch bases, coil forms, radio parts, insulation, nameplates, tubing and spacers. For bobbins and barrels in contact with delicate fibers of cotton, silk or rayon (textile equipment), grade X is recommended.

CHARACTERISTICS

GRADE X: Has high mechanical strength. Fair impact strength, resistance to splitting, electrical properties when dry, and resistance to moisture absorption. Semigloss finish on molded surfaces.

GRADE XX: Good electrical properties in both dry and fairly humid conditions, excepting high voltage or low power factor at high frequencies. Good resistance to moisture. Fair mechanical strength and low impact. Fair resistance to splitting. Semigloss finish on molded surfaces.

GRADE XXX: Best electrical properties. Low power factor. Good resistance to moisture. Fair mechanical strength and low impact. Fair resistance to splitting. Semigloss finish on molded surfaces.

All of these grades are opaque, subject to only slight cold flow, and the amount they darken under continuous exposure to sunlight is almost imperceptible. They have good resistance to continuous heat not higher than 212 degrees Fahr., and will not distort, but are subject to cracking at about 350 degrees Fahr. Hot water hastens absorption and swelling.

Choice between using rolled or molded tubing depends on several factors. Paper base rolled tubes generally have better dielectric strength, power factor and dielectric constant. Molded tubes usually have a lower percentage of moisture absorption. Where concentricity of outside and inside diameters is important, rolled tubes are recommended.

When using phenolic laminate in compression, load it flatwise. For applications where loading is tensile, use it edgewise and parallel to the fiber warp if possible. Where flexure is involved, loading should be flatwise at right angles to the fiber warp. In shear, loading should be flatwise.

Grade X has a kraft paper base. Grades XX and XXX have absorbent paper bases.

FABRICATION

MACHINABILITY:

About the same as for brass. This applies to operations such as sawing, drilling, tapping, milling and turning. Cutting tools, tungsten-carbide tipped or made of high-speed steel, are kept sharp to prevent the generation of excessive heat, as temperatures of 150 degrees Fahr. and over tend to delaminate these materials. No cutting compounds or lubricants are required. When machining is done parallel to the laminations, due care is exercised to prevent splitting.

PUNCHING:

Smaller clearances are used between punch and die than for punching metals. A good general rule to follow when laying out holes which are to be punched in sheets of these materials, is to make the distance between the holes and sheet edge three times the thickness of the sheet. Also, avoid specifying punched holes smaller in diameter than the thickness of the sheet. Often the sheet is heated to 120 degrees Cent. to prevent it from cracking during punching operations.

Punching Properties of Laminated Plastics

NEMA Grade	Max. Thickness (inches) for Best Results: Room Temp.	Approx. 120 deg. C.
X	1/32	3/32
XX	1/32	3/32
XXX	..	1/16

Of the three grades, XX has the best punching properties, XXX the poorest. Punched holes will shrink slightly whether material is punched hot or cold. Consequently, the punch should be made larger to compensate. For precision holes, stock is left on the diameter to permit finish drilling.

SHEARING:

For best edge finishes, none of these materials should be sheared at room temperatures in thicknesses greater than 1/32-inch. Maximum shearing thickness at 120 degrees Cent. is 1/8-inch.

BUFFING:

Polished surfaces are produced on a rag wheel, using standard polishing rouge. Care is exercised not to overheat the material.

RESISTANCE TO CORROSION

These materials are not affected by oils, gasoline, organic solvents, ketones or esters. Alkalies and acids, when weak, have slight effect. When subjected to strong alkalies and acids, however, these materials disintegrate.

DATA ON STOCK FORMS

Materials Work Sheet

Plate
STANDARD THICKNESS RANGES

NEMA Grade	Standard Thickness (inches) Minimum	Maximum
X	.010	2
XX	.010	2
XXX	.015	2

Plate
(all grades)
STANDARD THICKNESS TOLERANCES

Nominal Thickness (inches)	Plus or Minus (inches)	Nominal Thickness (inches)	Plus or Minus (inches)
.010	.002	7/16	.019
.015	.0025	½	.021
.020	.003	⅝	.024
.025	.0035	¾	.027
1/32	.0035	⅞	.030
3/64	.0045	1	.033
1/16	.005	1⅛	.035
3/32	.007	1¼	.037
⅛	.008	1⅜	.039
5/32	.009	1½	.041
3/16	.010	1⅝	.043
7/32	.011	1¾	.045
¼	.012	1⅞	.047
5/16	.0145	2	.049
⅜	.017		

Plate
(all grades)
TOLERANCES — CUT PIECES — LENGTH AND WIDTH

Nominal Thickness (inches)	Tolerance, Plus or Minus (inches) 6 inches and Under	Over 6 to 24 inches	24 inches and Over
.010 to ¼	.010	.015	1/32
17/64 to 12	.012	.017	1/32
33/64 to 1	.015	.020	1/32
1 1/64 to 1½	.018	.030	1/16
1 33/64 to 2	.022	.040	1/16

Plate
(all grades)
STANDARD TOLERANCES FOR WARP

Thickness (Inches)	Tolerance in Warp or Twist Expressed as Percentage of Lineal Dimension
Over 1/16 up to ¼	1%
Over ¼ up to ¾	½%
Over ¾	¼%

Plate, Round Tubing and Rod
STANDARD FINISHES

Form	Grade	Finish
Plate	XX, XXX	Semigloss or polished
Plate	X	Semigloss only
Round Tubing and Rod	X,XX,XXX	Ground, Buffed or Varnished

Plate
STANDARD COLORS

NEMA Grade	Standard Color
X	Natural, black or chocolate
XX	Natural or black
XXX	Natural or black

Round Rod
STANDARD RANGES OF OUTSIDE DIAMETERS

NEMA Grade	Standard Outside Diam. (inches) Minimum	Maximum
XX	⅛	2
XXX	⅛	2

Round Rod
SAW-CUT LENGTH TOLERANCES

Length (inches)	Tolerance — Plus or Minus (inches) for Rod of Following Diam. ⅛ to 1 15/16	2 to 4
0 to 3	.010	.010
From 3 to 6	.010	.015
From 6 to 12	.015	.020
Over 12	.030	.030

Round Rod
DIAMETER TOLERANCES

Diameter From	Up to and Incl.	Tolerance (inches) Plus or Minus
⅛	1 15/16	.005
2	4	.008

Round Tubing and Rod
(all grades)
STANDARD TOLERANCES FOR WARP

Outside Diameter (inches)	Tolerance in Warp Expressed as Percentage of Length
⅛ to ¼ incl.	2%
Over ¼ up to ¾	1%
Over ¾	½%

Round Tubing
(all grades)
STANDARD DIMENSIONAL STEPS—(inches)—INSIDE AND OUTSIDE DIAMETERS

Nominal I.D. and O.D. From	Up to and Including	In Steps of
⅛	1	1/32
1 1/16	3	1/16
3⅛	6	⅛
6¼	8	¼
8	25	½

Round Tubing
STANDARD SIZE RANGES—(inches)—INSIDE AND OUTSIDE DIAMETERS

NEMA Grade	Rolled Tubing Inside Diam. Min.	Max.	Outside Diam. Min.	Max.	Molded Tubing Inside Diam. Min.	Max.	Outside Diam. Min.	Max.
X	⅛	48	3/16	50	⅛	3⅞	¼	4
XX	⅛	48	3/16	50	⅛	3⅞	¼	4
XXX	None		None		⅛	3⅞	¼	4

Round Tubing. Rolled and Molded
(all grades)
TOLERANCES—INSIDE AND OUTSIDE DIAMETERS

Nominal I.D. and O.D. From (inches)	To (inches)	Tolerance — Plus or Minus (inches) Inside Diam.	Outside Diam.
⅛	15/16	.003	.005
¾	1 15/16	.004	.005
2	4	.008	.008
4⅛ (Rolled only)	12⅛	.010	.025

Round Molded Tubing
(all grades)
WALL THICKNESS TOLERANCES

Wall Thickness (inches)	Tolerance — Plus or Minus (inches) ⅛ to ¼-in. I.D. incl.	Over ¼ to ½-in. I.D. incl.	Over ½-in. I.D.
Less than 1/16	.008	.008	.008
1/16 and less than ⅛	.011	.011	.011
⅛ and less than ¼	.017	.015	.011
¼ to ½ incl.	.025	.018	.013

Round Molded Tubing
WALL THICKNESS TOLERANCES

Wall Thickness (inches)	Tolerance — Plus or Minus (inches) NEMA Grades X and XX
Less than 1/16	.006
1/16 and less than ⅛	.007
⅛ and less than ¼	.009
¼ to ½ incl.	.011

Round Tubing
(all grades)
SAW-CUT LENGTH TOLERANCES

Length (inches)	Tolerance — Plus or Minus (inches) for Tubing of Following Outside Diam. 3/16 to 2-in.	Over 2 to 4-in.	Over 4-in.
0 to 3	.010	.010	.030
From 3 to 6	.010	.015	.030
From 6 to 12	.015	.020	.030
From 12 to 48	.030	.030	.050

Materials Work Sheet

WEIGHTS OF SHEET, ROD AND TUBE

Number of Feet of Tube in One Pound

I.D. (inches)	Thickness of Wall (inches) 1/32	1/16	3/32	1/8	5/32	3/16	7/32	1/4	9/32	5/16	11/32	3/8
1/8	102.40	42.66	24.38	16.00	...	...	...	...	...	...	...	...
3/16	73.14	32.00	18.96	12.80	...	...	...	...	...	...	...	...
1/4	56.88	25.60	15.51	10.66	7.877	6.095	...	...	...	...	...	...
5/16	46.54	21.33	13.12	9.143	6.826	5.333	...	...	...	...	...	...
3/8	39.38	18.28	11.37	8.000	6.023	4.740	...	...	...	...	...	...
7/16	34.13	16.00	10.03	7.111	5.389	4.266	...	...	...	...	...	...
1/2	30.11	14.22	8.982	6.400	4.876	3.871	3.180	2.666	...	...	...	...
9/16	26.94	12.80	8.127	5.818	4.452	3.555	2.925	2.461	...	...	...	...
5/8	24.38	11.63	7.420	5.333	4.096	3.282	2.708	2.285	...	...	...	...
11/16	22.26	10.66	6.826	4.923	3.792	3.047	2.522	2.133	...	...	...	...
3/4	20.48	9.846	6.321	4.571	3.531	2.844	2.359	2.000	...	...	...	...
13/16	18.96	9.143	5.885	4.266	3.303	2.666	2.216	1.882	...	...	...	...
7/8	17.65	8.533	5.505	4.000	3.103	2.509	2.089	1.777	...	...	...	...
15/16	16.51	8.000	5.171	3.764	2.925	2.370	1.976	1.684	...	...	...	...
1	15.51	7.529	4.876	3.555	2.767	2.245	1.875	1.600	...	...	...	...
1 1/8	13.83	6.737	4.376	3.200	2.496	2.031	1.700	1.454	...	...	...	...
1 1/4	12.48	6.095	3.969	2.908	2.275	1.855	1.556	1.332	...	...	...	...
1 3/8	11.37	5.565	3.630	2.665	2.090	1.706	1.434	1.230	...	...	...	...
1 1/2	10.44	5.200	3.345	2.461	1.932	1.580	1.330	1.142	...	...	...	...
1 5/8	9.660	4.740	3.103	2.285	1.796	1.471	1.239	1.066	...	...	...	...
1 3/4	8.982	4.413	2.891	2.132	1.678	1.376	1.160	1.000	...	...	...	...
1 7/8	8.393	4.130	2.708	2.000	1.575	1.292	1.091	.941	...	...	...	...
2	7.877	3.878	2.547	1.882	1.483	1.219	1.030	.889	.773	.692	...	...
2 1/8	7.420	3.656	2.403	1.777	1.402	1.152	.975	.842	.739	.656	...	...
2 1/4	7.013	3.459	2.274	1.684	1.330	1.094	.926	.800	.702	.624	...	...
2 3/8	6.649	3.282	2.160	1.600	1.264	1.040	.881	.762	.669	.596	...	...
2 1/2	6.321	3.121	2.055	1.523	1.204	.992	.841	.727	.639	.569	...	...
2 5/8	6.023	2.976	1.961	1.454	1.150	.948	.804	.696	.612	.545	...	...
2 3/4	5.752	2.844	1.875	1.391	1.101	.908	.770	.667	.587	.522	...	...
2 7/8	5.505	2.722	1.796	1.333	1.055	.871	.739	.640	.563	.502	...	...
3	5.278	2.611	1.723	1.280	1.013	.837	.710	.615	.542	.483	.435	.395
3 1/8	5.069	2.509	1.656	1.231	.994	.805	.683	.593	.522	.465	.419	.381
3 1/4	4.876	2.414	1.595	1.185	.936	.776	.659	.572	.504	.449	.405	.368
3 3/8	4.697	2.326	1.543	1.143	.906	.749	.636	.552	.486	.434	.391	.355
3 1/2	4.531	2.245	1.483	1.103	.857	.724	.615	.534	.471	.420	.378	.344
3 5/8	4.376	2.169	1.434	1.066	.846	.700	.595	.516	.455	.406	.366	.333
3 3/4	4.231	2.097	1.387	1.032	.819	.677	.576	.500	.441	.394	.355	.323
3 7/8	4.096	2.031	1.343	1.000	.794	.656	.558	.485	.428	.382	.345	.314
4	3.969	1.968	1.302	.970	.770	.637	.542	.470	.415	.371	.335	.305
4 1/8	3.849	1.910	1.263	.942	.748	.618	.526	.457	.404	.360	.325	.296
4 1/4	3.736	1.854	1.227	.914	.726	.601	.512	.444	.392	.350	.317	.288
4 3/8	3.630	1.802	1.193	.889	.706	.584	.498	.432	.381	.341	.308	.280
4 1/2	3.531	1.752	1.161	.865	.687	.569	.484	.421	.372	.332	.300	.273
4 5/8	3.435	1.706	1.130	.842	.669	.552	.472	.410	.362	.324	.293	.266
4 3/4	3.345	1.662	1.101	.821	.652	.538	.460	.400	.354	.316	.285	.260
4 7/8	3.260	1.620	1.073	.800	.636	.527	.448	.390	.345	.308	.279	.254
5	3.180	1.580	1.047	.776	.621	.514	.438	.381	.336	.301	.272	.248
5 1/8	3.103	1.542	1.022	.762	.606	.502	.428	.372	.329	.294	.266	.242
5 1/4	3.029	1.505	.999	.745	.592	.493	.418	.364	.321	.287	.260	.237
5 3/8	2.959	1.471	.976	.727	.579	.479	.408	.355	.314	.281	.254	.232
5 1/2	2.892	1.438	.954	.711	.566	.469	.400	.348	.307	.275	.249	.227

Approximate Weights of Standard 36 by 36-inch Phenolic Laminate Sheets

Thickness (inches)	Weight (lbs.)	Thickness (inches)	Weight (lbs.)	Thickness (inches)	Weight (lbs.)
1/64	1	3/8	24	1 1/2	96
1/32	2	7/16	28	1 3/4	112
1/16	4	1/2	32	2	128
3/32	6	3/4	48	2 1/2	160
1/8	8	7/8	56	3	192
5/32	10	1	64	3 1/2	224
3/16	12	1 1/8	72	4	256
1/4	16	1 3/16	86	4 1/2	288
5/16	20	1 1/4	90	5	320

Weights of 100 foot Lengths of Phenolic Laminated Rods

Diameter (Inches)	Weight (lbs.)	Number of ft. per lb.	Diameter (Inches)	Weight (lbs.)	Number of ft. per lb.
3/32	.41	241.43	13/16	31.11	3.22
1/8	.74	135.80	7/8	36.08	2.77
3/16	1.65	60.36	15/16	41.42	2.42
1/4	2.95	33.95	1	47.12	2.12
5/16	4.60	21.73	1 1/8	59.64	1.68
3/8	6.62	15.09	1 1/4	73.63	1.36
7/16	9.02	11.09	1 3/8	89.09	1.12
1/2	11.79	8.49	1 1/2	106.03	.943
9/16	14.91	6.71	1 5/8	124.42	.803
5/8	18.40	5.43	1 3/4	144.32	.693
11/16	22.27	4.49	1 7/8	165.67	.604
3/4	26.51	3.77	2	188.50	.530

MATERIAL TRADENAMES

Tradenames	Producers	Tradenames	Producers
Dilecto	Continental-Diamond Fibre Co.	Panelyte	Panelyte Division St. Regis Paper Co.
Farlite	Farlite Division Farley & Loetscher Mfg. Co.	Insurok	Richardson Co.
Formica	Formica Insulation Co.	Spauldite	Spaulding Fibre Co.
Lamicoid	Mica Insulator Co.	Synthane	Synthane Corp.
Phenolite	Phenolite Division National Vulcanized Fibre Co.	Micarta	Micarta Division Westinghouse Electric & Mfg. Co.

Parts Production Speeded by Impact Extrusion*

By Phil Koenig
Consolidated Vultee Aircraft

MANY airplane parts which would normally be produced by casting, forging, or by machining from solid stock, can be produced rapidly and economically by the impact-extrusion method.

Aluminum and aluminum alloys can be extruded by impact. The only limit to the size of parts so produced is the power of the press that can be obtained for the work. Small parts can be produced on standard crank presses which are available in almost every shop. Any type of press can be used, as it is not necessary to have a high speed, except, of course, in respect to production capacity. Hydraulic presses can be used to advantage. Small parts can be produced in multiple dies and, in this way, much larger production obtained.

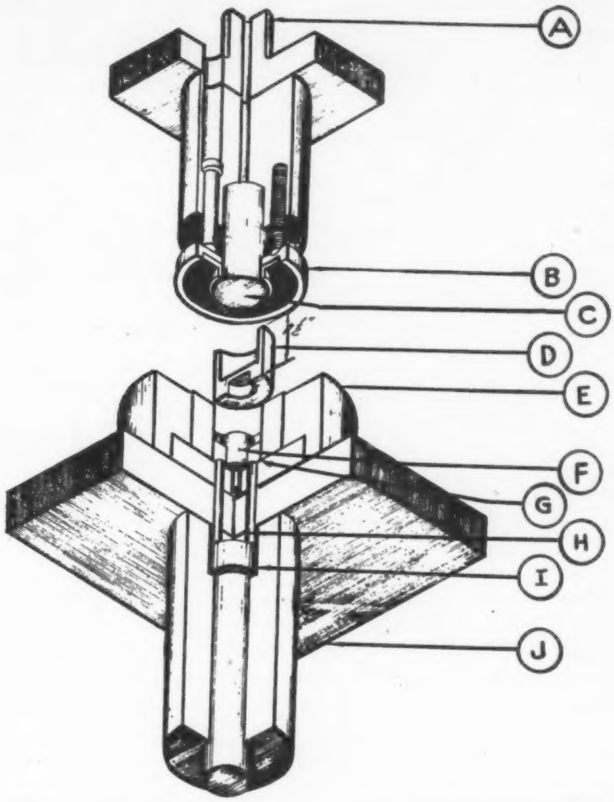
Impact extrusion can be used advantageously as a method of producing a satisfactory substitute for many parts that are now being made by the drop-hammer process. Because of the increasing difficulty in obtaining forgings, this substitute method should be rapidly promoted and used to the maximum extent possible.

Dies for the manufacture of parts produced by the impact-extrusion method must have sufficient strength and proper heat treatment to withstand the extreme pressures and impact shocks under the continuous operation imposed. During the flow period through which the metal passes there is, as a consequence of the high pressures between the die surfaces and the flowing metal, considerable friction and, as a consequence, wear to be considered. It has been found that a plating of chromium is advantageous, as it materially lengthens the life of the dies.

There are many advantages to this form of production. These can be roughly enumerated as follows:

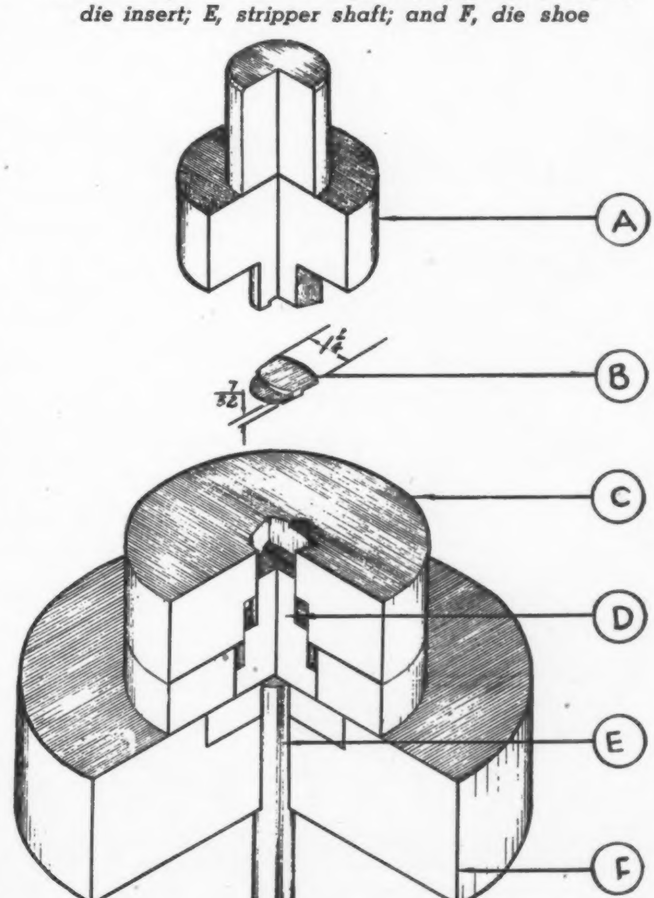
1. Density of the metal is considerably increased; consequently, the metal is not harmed by this process. On the contrary, material improvement is brought about.

2. Tool cost is relatively low. Dies, in the majority of cases, can be easily machined. There is no special skill required in the production of these dies over those of other methods. Tools for this method do not require any special care in the course of their creation. There are

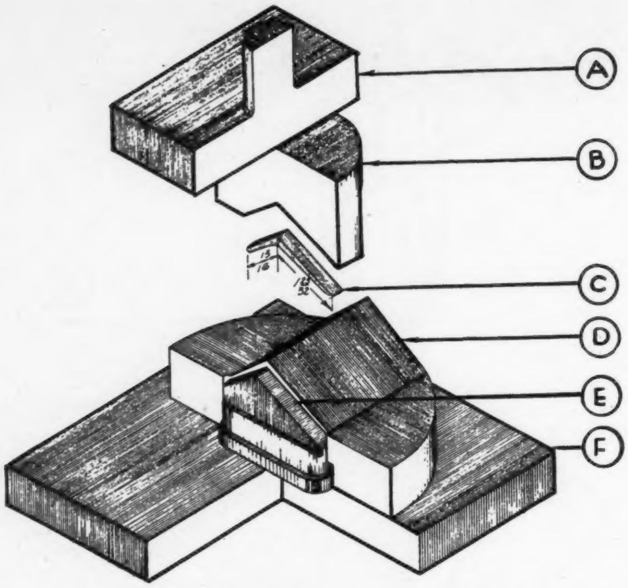


Above—Impact extrusion die. A is punch assembly; B, stripper plate; C, punchinsert; D, part; E, die assembly; F, die form punch; G, stripper pad; H, stripper pins; I, stripper shaft; and J, die shoe.

Below Coin-press die. A is punch; B, part; C, die; D, die insert; E, stripper shaft; and F, die shoe



*Abstract of paper presented at an SAE National Aircraft Production Meeting, Los Angeles, Calif.



Left—Die for impact extruding or coining. A, punch holder; B, punch; C, part; D, die; E, die insert; F, die plate

only a comparatively few simple rules to be followed.

3. Low production cost is obtained, as skilled labor is unnecessary. Parts produced by impact extrusion, once the dies are created, require merely the insertion of the blank or slug in the die cavity and the removal of the finished parts after the power stroke has been completed. Both of these can be done by means of a properly designed feeding mechanism. A combination of this character would, although needed only for large quantity production, be extremely efficient.

4. Extremely close tolerances are automatically obtained. Tolerances, when using this method, warrant no special consideration. This is radically different from any other system. Here, close tolerances are ensured and at no expenditure of time, either in making the parts or in their inspection.

5. There are no set limitations in regard to the form or shape of the parts which can be produced by the impact method, although symmetrical and cylindrical shapes might be best suited as far as the tools are concerned. Square, rectangular and oval, as well as unsymmetrical shapes, can be produced with equal ease once the tools have been made. There is no limit to the height to which a slug can be driven.

There is another consideration that might be given here, namely, that of producing parts with holes or openings. Sometimes it might be best to drill, punch, or otherwise make these after the part has been completely formed. There are other times, however, when this is not the case and the opening should be made in the slug or blank.

Care must be given, it has been found, to the design and fit of all dies, so as to prevent the metal being formed from being forced into the clearance spaces between the die body and the knock-out plunger. The high pressures involved necessitate close fits in this respect, but no particular difficulty need be expected.

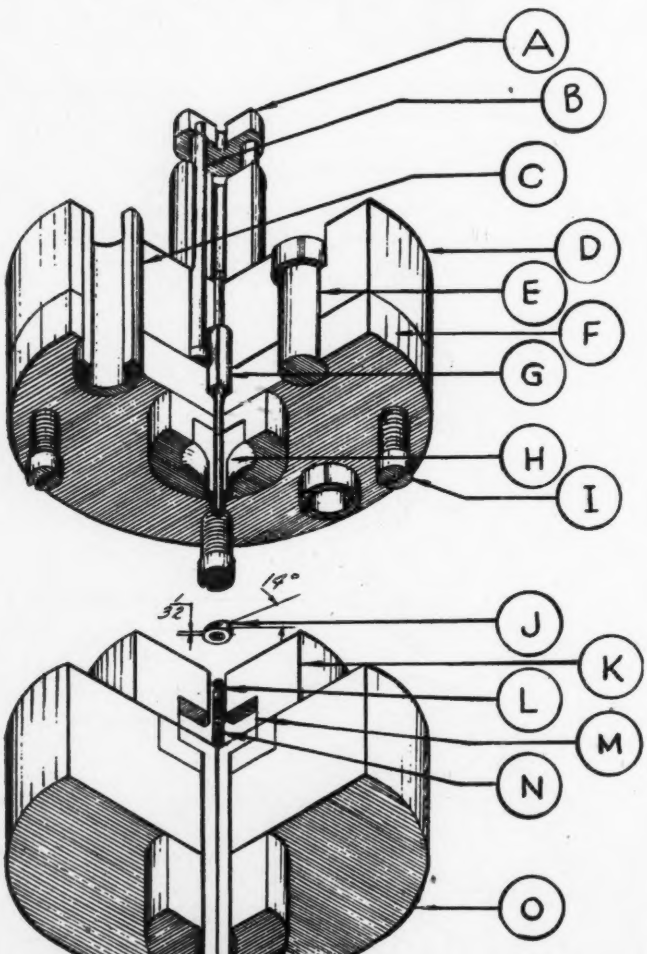
6. Secondary operations, wherever necessary, can greatly broaden the field to be covered by this system of production. It has been prophesied, and we believe correctly, that impact extruding will be used extensively in the production of aeronautical parts. This will not only aid materially in obtaining items otherwise requiring production by the drop-hammer method, but will be the means of more efficiently producing parts made on the turret lathe, milling machine, or by other similar methods.

7. Thermal methods can be used to supplement the strain-hardening improvement brought about by this method.

8. Complicated designs and shapes can be produced which would be difficult or impossible to produce by any other method and, with properly constructed dies, they are obtained with the same ease as the simplest pieces.

In these hectic days wherein skilled help is at a premium, wartime emergency demands the use of every facility and every method that Yankee ingenuity and industrial development can bring about. This is one of a number that have already been utilized in production that will help in the dire competition which exists between our scientific and productive efforts and those of our enemies.

Below—A true coining die. A, punch plate; B, punch pin; C, guide bushings; D, punch shoe; E, guide pin; F, punch holder; G, locating pin; H, punch insert; I, stripper spring screws; J, part; K, die holder; L, locating pin; M, die; N, locating pin spring; O, die shoe; P, knock-out shaft



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. . . is the one that fails. To determine the real price of faulty bearings take the original cost and add the expense of installation. Then include the productive time lost while the machine is down.

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Johnson Bronze offers manufacturers in every type of industry the highest quality SLEEVE TYPE Bearings on the market. Johnson Sales Engineers are available at all times to give sound advice on the installation and maintenance of bearings. Real bearing values are figured in terms of performance . . . not purchase price.

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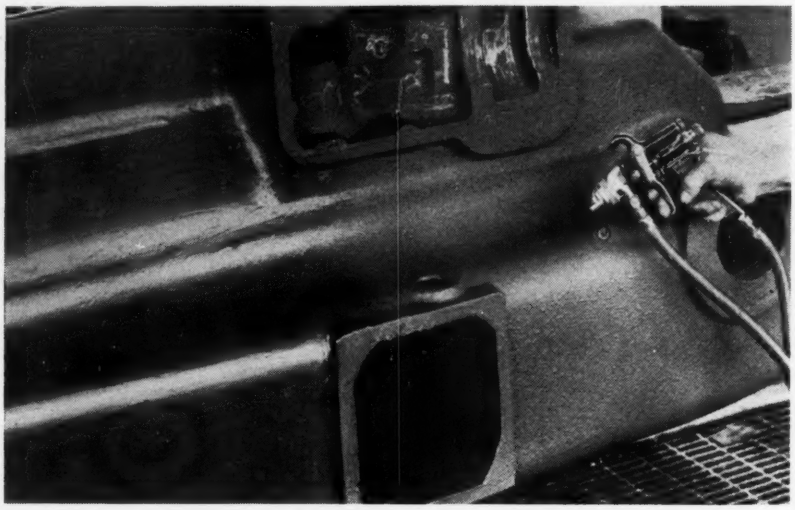
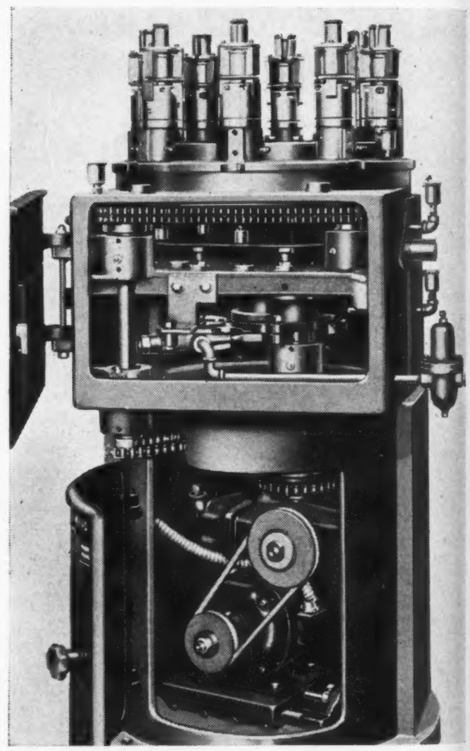
Applications

of Engineering Parts, Materials and Processes



Chains Drive Indexing Table

NOTEWORTHY among the variety of drives incorporated in the indexing table of the Hammond rotary automatic, shown below, is the extensive use of roller chains. Table work spindles which hold parts for deburring, brushing, polishing, or buffing are chain-driven from a vertical countershaft visible at the left of the machine. Countershaft in turn is driven by a chain from a speed reducer located in the lower part of the base, which also drives through another chain the geneva lever shaft for indexing the table.



Finishing Cast Surfaces

WARTIME restrictions on materials for finishing rough surfaces of machines permit only one coat of primer or sealer and two coats of paint, enamel or lacquer, no filler being allowed. However, surface defects cannot be removed without the aid of a filler or prolonged grinding which consumes too much time, and such defects are magnified by the usual glossy reflecting surface. As a solution, the Cincinnati Bickford Tool Co. is using a spatter-type or pebble finish on their drills.

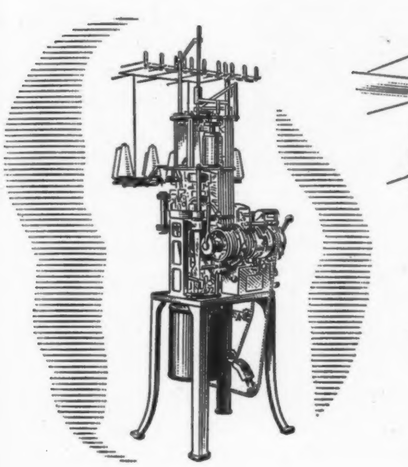
Developed by The Sherwin-Williams Co., this finish renders surface defects practically invisible and requires only one coat of primer to produce a uniform and attractive finish. Primer coat is brushed on to insure greater penetration while the pebble finish is, of course, sprayed on as shown above. Drying time for each coat is ten minutes. The tool is then given a finish coat of standard machine-tool gray. The new finish requires from one-third to one-half less time, effort and material than the method hitherto used.

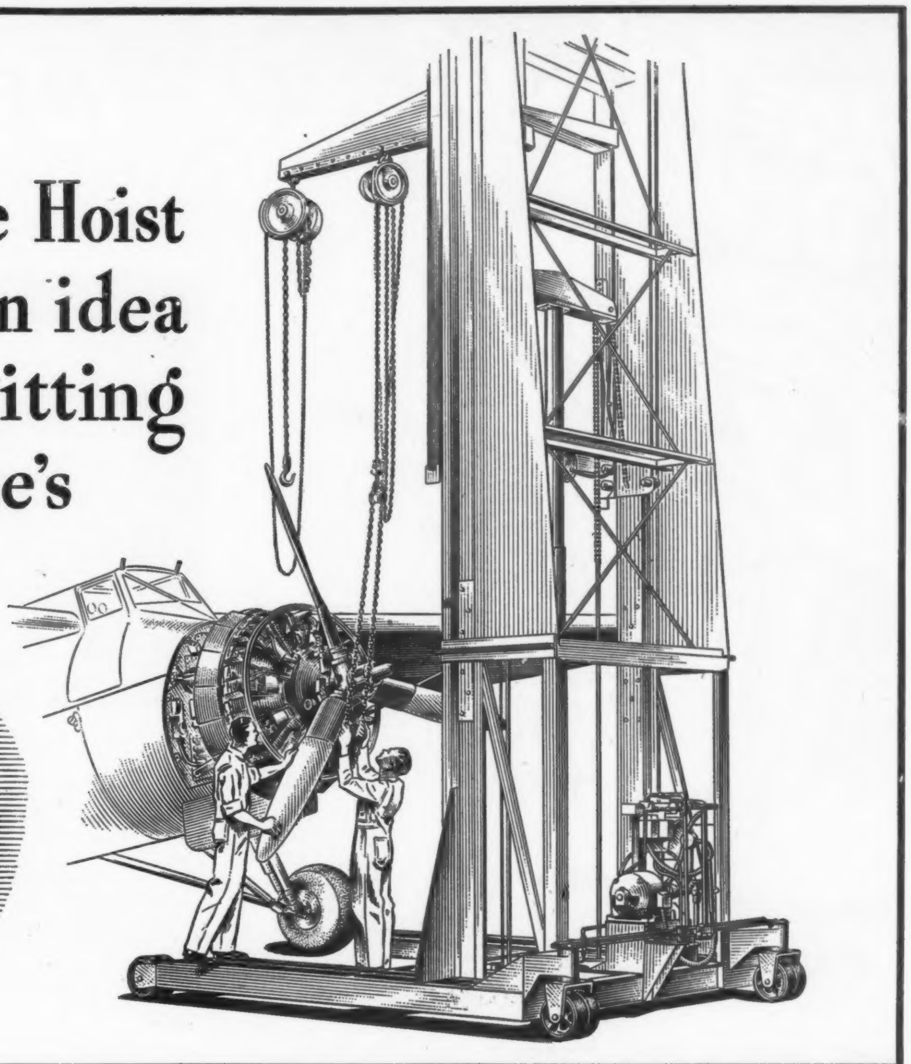
Prefabricated Housings for Machines

HOUSINGS for the Wurton automatic tobacco dryers shown below are prefabricated light steel Lindsay Structure. The housing provides an airtight enclosure for the machine through which tobacco is carried on a wide conveyor belt while currents of warm air circulate over it, removing excess moisture.

Erection requires a minimum of time and labor as all parts are accurately die-formed and can be quickly put together with simple wrenches, no welding, cutting or fitting being necessary on the job. Where plant expansion requires it, machines incorporating these housings can readily be disassembled and re-erected in a new location.

The Engine Hoist *"Lifted"* an idea of the Knitting Machine's





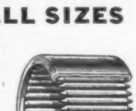
PERHAPS IT SEEMS ODD—an aircraft engine hoist picking up an idea it could use—in a textile mill. Builders of knitting machinery are constantly striving for speed and more speed, greater efficiency of operation. Small wonder the knitting industry was among the first to adopt the Torrington Needle Bearing—its low coefficient of friction insured quicker response, and efficient lubrication permitted operation over long periods without *any* attention.

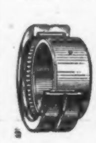
But the aircraft engine hoist is in no great hurry. How much overloading it could stand, and how dependable it might be—particularly at flight bases in steaming jungle, arid desert and frozen wasteland—concerned hoist designers principally. Yet *they* specified the Needle Bearing—for high load capacity and reliable performance. But in this unique anti-friction bearing's combination of features were several others that came in handy, helped equip our aircraft industry and air forces with engine hoists often surpassing specifications, and in less time, too.

For the Needle Bearing's low coefficient of friction speeded aircraft engine installation and overhauling . . . its simple, effective system of lubrication reduced maintenance time and expense . . . its long service life helped "keep 'em flying," while ready availability, for such essential applications as aircraft engine hoists, was and *is* an important factor in today's staggering plane production totals and our sustained air attacks on enemy bases.

NEEDLE BEARINGS—ALL TYPES—ALL SIZES

NEEDLE BEARINGS TYPE DC are complete, self-contained units consisting of a full complement of rollers and a drawn, hardened outer race. They offer the advantages of small size, low cost, high capacity—and easy installation.





NEEDLE BEARINGS TYPE NCS consist of a full complement of rollers and a relatively heavy hardened outer race. They are furnished with or without inner races. Needle Bearings Type NCS are adaptable to heavier loads than Needle Bearings Type DC.

NEEDLE ROLLERS TYPE LN are produced in a range of types and sizes for assembly on the job into low-cost, high-capacity, anti-friction bearing units. Our engineering department will be glad to advise on the correct size and type for any application.

DOES THIS SUGGEST ANYTHING TO YOU in considering your product's design for postwar? There are any number of opportunities for increasing efficiency and reducing costs through the Needle Bearing's combination of features. And you'll have a real sales story! For Tomorrow's customers will be looking for the very advantages the Needle Bearing offers in the products they buy—light weight, compact design, easy operation, efficient lubrication, minimum maintenance. Send for Catalog No. 109 covering sizes, types and ratings, as well as list of typical applications of the Needle Bearing. In working out details, Torrington engineers will gladly help you.

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LET'S GO! U.S.A. KEEP 'EM FLYING!

TORRINGTON NEEDLE BEARINGS

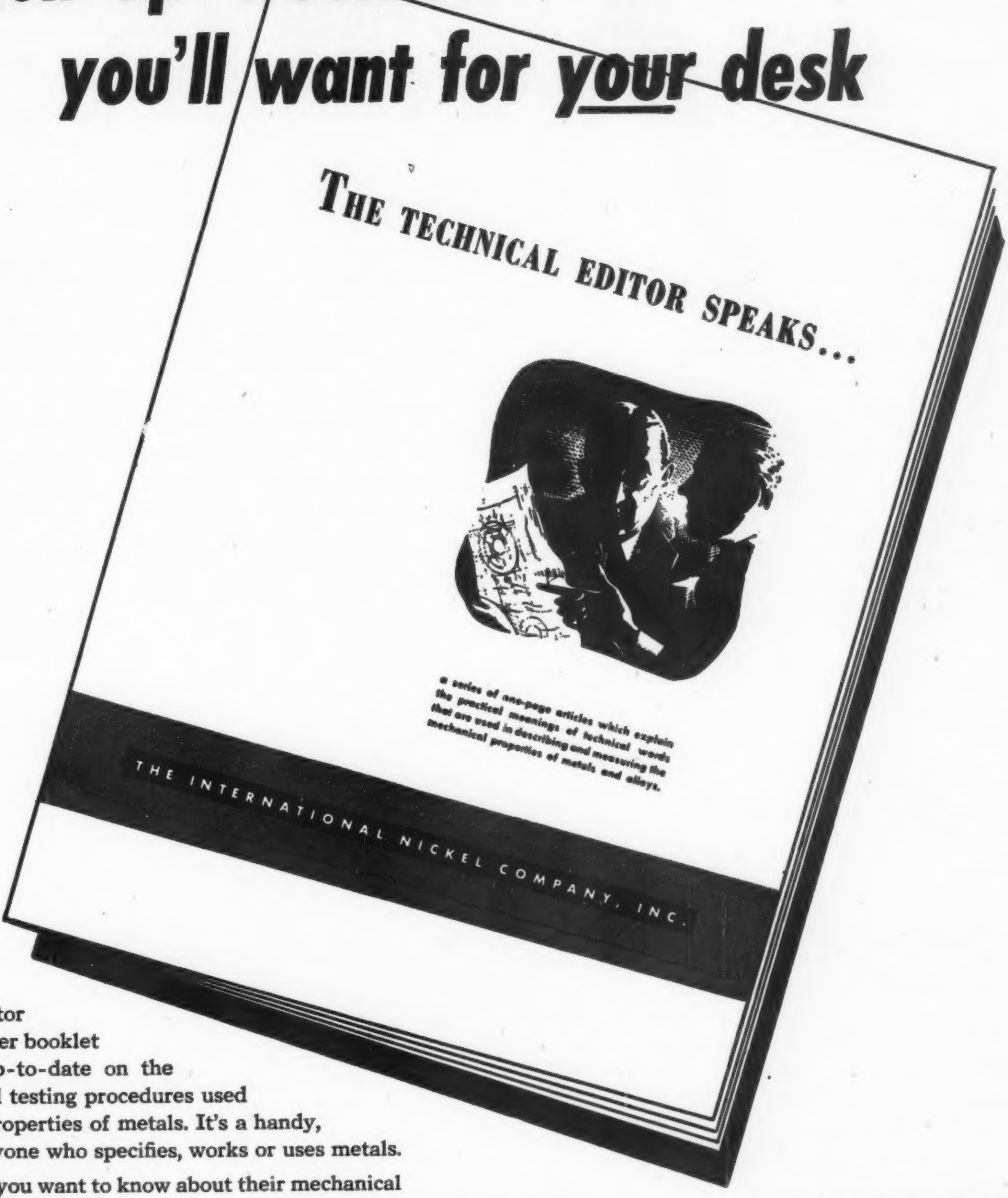
MEN OF MACHINES

ELECTION of James Y. Scott as president of the National Machine Tool Builders' association for the coming year places in this responsible position a man whose executive and engineering ability is best attested by the impressive and continuous growth of the Van Norman Co., of which he is president, treasurer and general manager. Mr. Scott, born in Dundee, Scotland, entered the employ of the Van Norman Machine Tool Co. in its drafting room. He was successively draftsman, layout man, salesman, assistant to the president, general sales manager, and in 1936 executive vice president, general manager and treasurer of the company. He held these positions until 1940 when he became president and treasurer. Mr. Scott is a member of the Society of Automotive Engineers and American Society of Tool Engineers.

♦

". . . one of the household appliance industry's outstanding engineers brings with him a wealth of 'know how' in appliance engineering that should prove of material benefit to our company in the years ahead," said R. L. White, president of Landers, Frary & Clark, when announcing the appointment of William James Russell as vice president in charge of engineering for the Landers organization. Mr. Russell was formerly manager of appliance engineering at Westinghouse. Born in 1894 in Scotland, Mr. Russell studied mechanical engineering at Heriot-Watt Technical college, but before completing his course he entered the World War. After the war he was sent to Germany with the Army of Occupation and remained there until 1919 when he was transferred to the British Naval Torpedo factory as test engineer. A year later he came to the United States and for nine months worked for R. & J. Hoe Printing Press

A "Brush-Up" Booklet you'll want for *your* desk



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....

Co. In June, 1924 he joined Westinghouse where he attended the company's school of motor design, gathering engineering knowledge that later proved invaluable. From the position of development engineer for manufacturing, engineering and cost reduction departments, he was transferred in 1932 to the company's electric appliance division where in two years he became manager of engineering in charge of all engineering and development work on appliances.

◆

AMONG other engineering appointments of Gar Wood Industries Inc., is that of George D. Shaeffer to the position of chief engineer of the company's engineering departments. Prior to this appointment Mr. Shaeffer had been chief engineer of the road machinery division. Born in Paulding, O., he obtained his mechanical engineering degree in 1921 from Ohio Northern university. Upon graduating he joined W. A. Riddell Co., where he served for several years as chief engineer. In 1935 he became connected with Allis-Chalmers Mfg. Co. Here he was in charge of engineering for the company's road machinery department. Three years later he joined the Gar Wood organization as chief engineer of its road machinery division. As mentioned, he served in this capacity until his present appointment as chief engineer of all the company's engineering departments.

◆

W. W. GALBREATH has been appointed executive vice president of the Pressed Metal Institute. A recently organized research division will be primarily concerned with opportunities of pressed metal in postwar production and the speeding of redesign and conversion, to which Mr. Galbreath will devote special attention.

◆

WILLIAM J. PRIESTLEY has resigned as chief of the alloy steel branch, steel division, War Production Board, to return to his post as vice president in charge of research and development of Electro Metallurgical Co.

◆

ERNEST W. SEAHOLM who for twenty-two years has been chief engineer of Cadillac Car Division, Detroit, has resigned and will devote most of his time to consulting work relative to war production problems. Succeeding Mr. Seaholm as chief engineer at Cadillac is JOHN F. GORDON who has been with the organization for eighteen years, most recently in supervisory capacities.

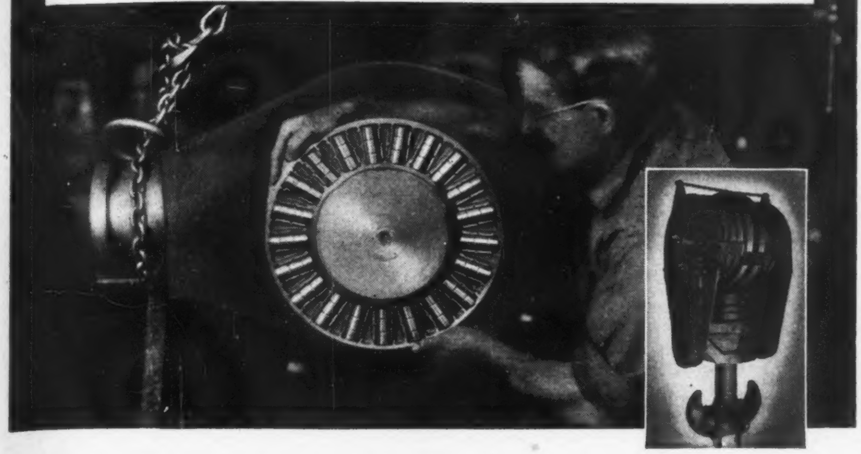
◆

T. W. LORING, formerly assistant chief engineer, Eastern Aircraft division, General Motors Corp., Trenton, N. J., has been retransferred to his former position as

(*Continued on Page* 174)

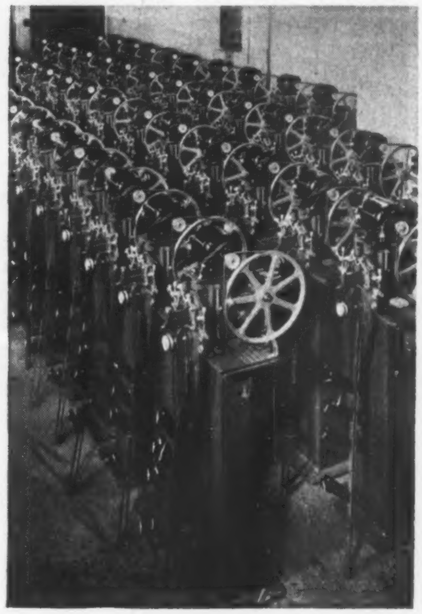
IN THE NEWS

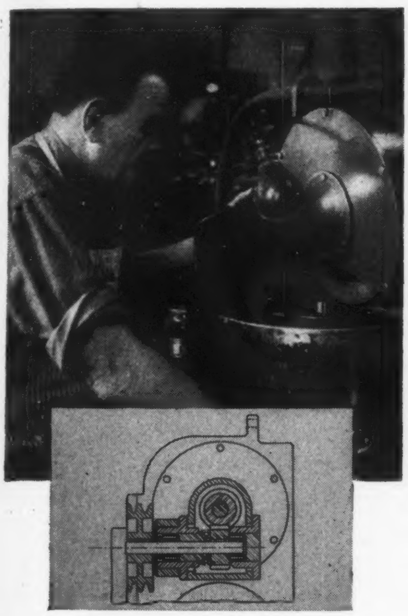
WITH TORRINGTON—BANTAM

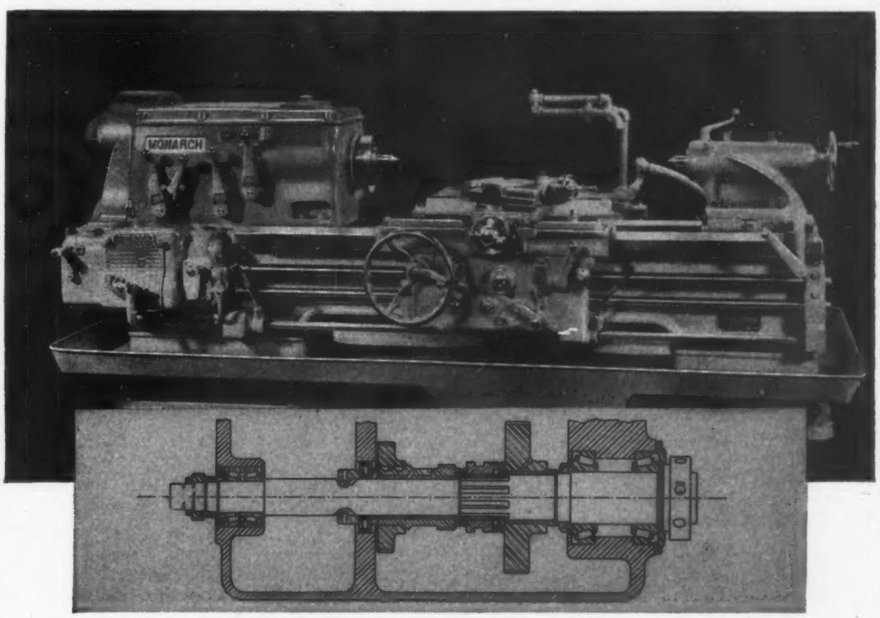


A LARGE PRECISELY CONSTRUCTED ROLLER THRUST BEARING, measuring over a foot in diameter, enables the giant 5½-ton hook, shown in the inset, to rotate smoothly and safely, even when encumbered by its 150-ton capacity load. When the Shepard Niles Crane and Hoist Corporation custom-designed this load block, which is to hang from an overhead electric traveling crane in a West Coast shipyard, they selected a Type LR-71 Roller Thrust Bearing for the yoke bearing because of its compact design which provides a static capacity of 155 tons. This is an excellent example of Torrington's ability to design and build bearings for unusual applications.

FILING SAW TEETH on hand, band and circular saws for the Army Air Corps is the destiny of these Automatic Saw Filers built by the Foley Manufacturing Company. The precise action needed to obtain accurate file cuts depends to a large extent upon the use of compact, high capacity NCS Needle Bearings.







GRINDING OF GEARS, WASHERS and rolls is done rapidly and accurately with this Rotary Surface Grinder made by the Arter Grinding Machine Company. In the four-speed change gear mechanism for the drive to the magnetic chuck, the makers have specified Type NCS Bearings with their compact design and high load capacity. Bearing application is shown in the accompanying cross-section.

BECAUSE OF THEIR LIGHT WEIGHT, low coefficient of friction and high lubricant capacity Needle Bearings serve a wide variety of special applications. If you have a seemingly difficult bearing problem, it may be solved quickly and easily by reference to Torrington-Bantam's complete line of Needle Bearings of all types and sizes. Whatever your bearing problem, TURN TO TORRINGTON for expert engineering counsel.

NEW STANDARDS OF ACCURACY and performance in metal turning have been developed through the generous use of anti-friction bearings in this Model "M" 16-Speed Engine Lathe built by The Monarch Machine Tool Company. Giving high capacity in a minimum of space, Torrington Radial Roller Bearings have been used as the center support of the spindles of these lathes, as shown graphically in the accompanying cross-section.

ARMY (E) NAVY

TORRINGTON BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION
SOUTH BEND 21, INDIANA

(*Continued from Page* 170)

body engineer, Oldsmobile division, General Motors Corp., Lansing, Mich.

•

Helmuth G. Braendel has been transferred from supervisor of the dynamotor laboratory to chief development engineer at Continental Motors Corp., Detroit.

•

Karl H. Britton, previously vice president of engineering, Britton Controls Inc., Cleveland, is now in the development engineering department of Thompson Products Inc., Cleveland.

•

Albert A. Arnhym has joined Solar Aircraft Co., San Diego, Calif. as consulting engineer. Prior to his appointment he had been chief engineer, Pacific Airmax Corp.

•

C. W. Van Ranst has become connected with F. L. Jacobs Co., where he will design and develop engines. He resigned from the engineering department of Ford Motor Co. recently.

•

Lawrence B. Jackson has recently been appointed director of engineering for the diesel division of American Locomotive Co.

•

C. Morgan Rifenbergh has become associated with Westinghouse Electric & Mfg. Co., Lima, O. as design and development engineer. He had been a physicist at Federal Telephone & Radio Corp., New York city.

•

For the most conspicuous contribution to research, standardization and advancement of welded construction, David S. Jacobus, retired consulting engineer of the Babcock & Wilcox Co., Barberton, O., received the Samuel Wylie Miller Memorial Medal awarded recently at the annual meeting of the American Welding Society. Dr. Jacobus, born in Ridgefield, N. J., in 1862, was graduated from Stevens Institute of Technology in 1884 and received his degree of doctor of engineering from the same university in 1906. He taught experimental mechanics and engineering of physics at Stevens from 1884 to 1906. Later he joined the Babcock & Wilcox Co. as advisory engineer and was also head of the engineering department. Author of many papers and considered one of the world's authorities on steam engineering, Dr. Jacobus is a member of nine societies. He has served as president of the American Welding Society, the American Society of Refrigerating Engineers and the American Society of Mechanical Engineers. He followed developments in welding closely and, seeing the possi-

bilities, was influential in bringing about more liberalization of the rules dealing with the welding of pressure vessels. Suitable safety was provided so that at present there is no limitation on the use of welding for any thickness or size of pressure vessel providing welding is properly done and meets required tests. Dr. Jacobus has also been a recipient of the Morehead Medal of the International Acetylene association and was declared a "Modern Pioneer" by the National Association of Manufacturers.

♦

S. I. Cole was elected a member of the executive committee of the Radio Manufacturers association at its annual convention recently. He is president of Aerovox Corp.

♦

Robert A. Boyer, designer of the first all-plastic automobile body, has resigned from his post as chief of research, Ford Motor Co.

♦

W. H. Aubrey, vice president of Frick Co., is the new president of the Air Conditioning and Refrigerating association.

♦

Andrew F. Haiduck has been made vice president in charge of engineering at Bellanca Aircraft Corp., Wilmington, Del.

♦

Thomas A. Morgan has been awarded the honorary degree of doctor of engineering by the University of North Carolina. Mr. Morgan is president of Sperry Corp.

♦

Alvin J. Herzig, chief metallurgist, has been elected vice president in charge of research, Climax Molybdenum Co., succeeding William P. Woodside who is retiring after seventeen years with the company.

♦

Robert H. Wendt, formerly chief engineer, has been elected vice president of Taylor Aircraft Aviation Corp.

♦

Edwin D. Eaton has been made administrative engineer of Hamilton Standard Propeller division, United Aircraft Co., East Hartford, Conn. Other appointments include those of Murray C. Beebe, chief development engineer; Glenn T. Lampton, chief experimental engineer; Charles M. Kearns Jr., chief research engineer; and Charles B. Conwell, senior engineer.

♦

Thomas E. French has been awarded the Lamme Medal for meritorious achievement in engineering. He is professor emeritus of engineering drawing in the engineering department at Ohio State university.

♦

A. C. Berg has been appointed manager of the road machinery division of Gar Wood Industries Inc.

♦

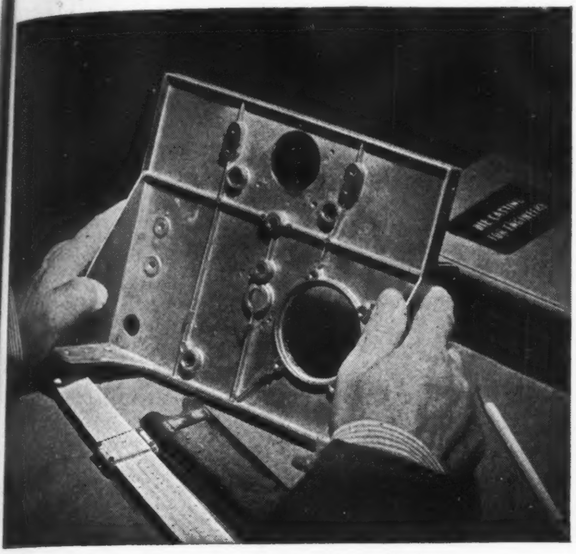
John Tjaarda, design and research engineer, has joined the Accurate Engineering Co.

♦

W. S. Edsall, who has an extensive background in the electrical field particularly in the design and production of control equipment, has been made manager of a newly combined switchgear and control division of Allis-Chalmers Mfg. Co.

FOR WAR TODAY—FOR YOUR PRODUCTS TOMORROW

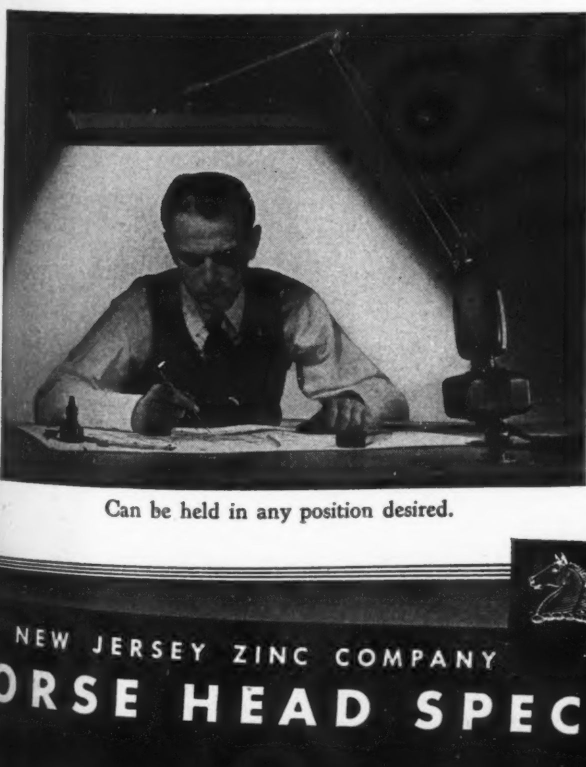
DIE CAST OF ZINC ALLOY —TO SAVE $3.37 PER PART



A part for an aviation training device.

The zinc alloy die casting shown above — machined and ready for assembly — costs $3.63. As originally produced by another method, of another material, it cost $7.00. And this saving is realized despite a comparatively small number of castings required. The casting is employed in a device for training aviation students in blind flying.

Although the economic advantages of zinc alloy die castings are now well known among design engineers, the impression may exist that these economies are true only when long production runs are involved. The above application is one of many which dispel this misconception.



Can be held in any position desired.

THE New Jersey Zinc ALLOY POT

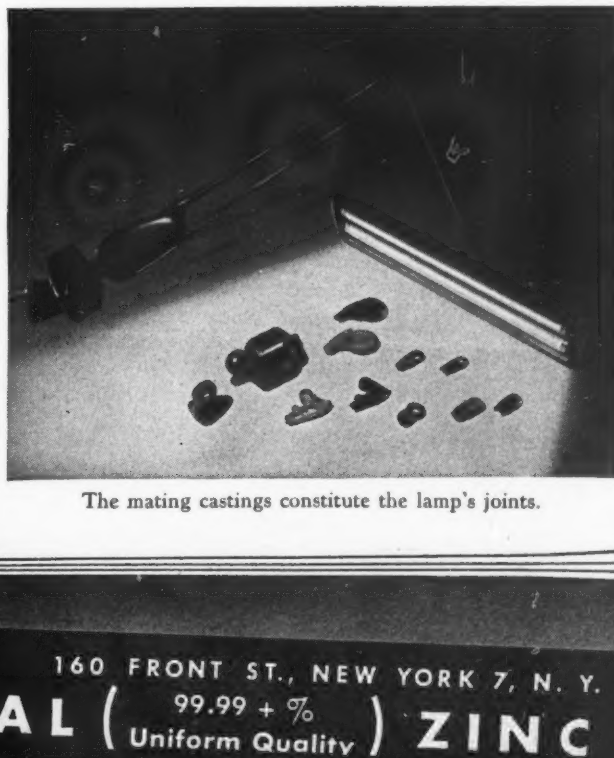
A publication issued for many years by THE NEW JERSEY ZINC COMPANY to report on trends and accomplishments in the field of die castings. Title Reg. U. S. Pat. Off.

MACHINE DESIGN EDITION **No. 15**

11 DIE CASTINGS GIVE MAXIMUM ADJUSTMENT

The lamp shown below features unusual adjustability—to carry the light source in a six foot spherical field. Its die cast joints—and an ingenious balancing mechanism—permit the reflector to be held in any position desired. This lamp is serving in the 'round the clock operation of war plants and engineering offices. It also serves to emphasize the many advantages of zinc alloy die castings.

Consider the 11 zinc alloy die castings from these standpoints: *unusual shapes* in one piece to minimize the number of parts and assembly operations required; *accuracy of dimensions* for the snug fit of mating parts; *smooth surfaces as-cast* for easy finishing in rich brown enamel; *low cost production* through the elimination of machining.



The mating castings constitute the lamp's joints.

THE NEW JERSEY ZINC COMPANY
160 FRONT ST., NEW YORK 7, N. Y.

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

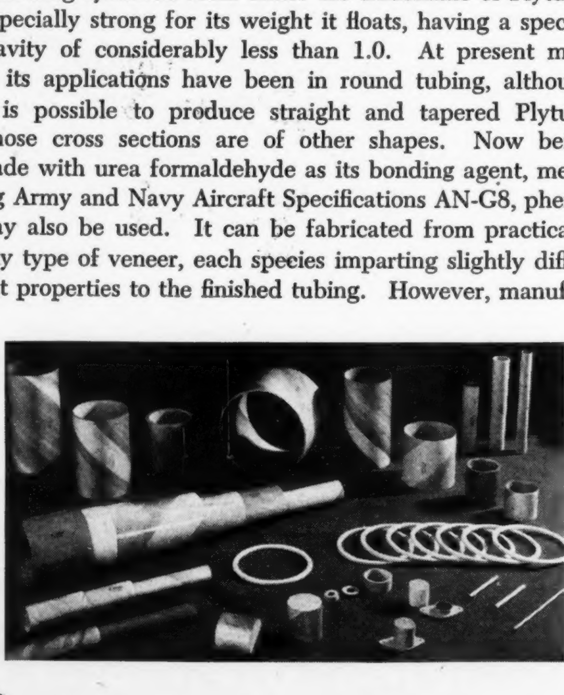
New PARTS AND MATERIALS

Small Sized Seal-Less Pump

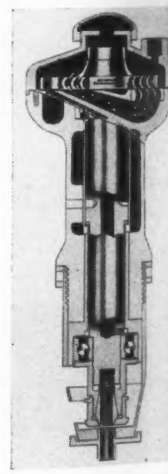
IDENTIFIED as Model MVA, another small sized seal-less pump has been announced by Pioneer Pump & Mfg. Co., 19669 John R street, Detroit 3. It was designed for machines such as hand mills, surface grinders, internal grinders, drill presses, tapping machines, and the like. Just short of 16 inches in height, the pump has all the characteristics built into the full-sized pumps. Being a submerged type, the model is intended for machines having a coolant sump in their base or for machines provided with separate coolant tanks. In the latter case, brackets and flanges are available for mounting the pump on the edge, side or top. Chips or dirt that will pass through the grille located in the bottom of the pump will readily pass through the pump without injuring it.

Plywood Tubing Available

PLYWOOD tubing is being fabricated by Plymold Corp., Lawrence, Mass., from thin veneers and a thermosetting synthetic resin under the tradename of Plytube. Especially strong for its weight it floats, having a specific gravity of considerably less than 1.0. At present most of its applications have been in round tubing, although it is possible to produce straight and tapered Plytube whose cross sections are of other shapes. Now being made with urea formaldehyde as its bonding agent, meeting Army and Navy Aircraft Specifications AN-G8, phenol may also be used. It can be fabricated from practically any type of veneer, each species imparting slightly different properties to the finished tubing. However, manufacturing is now limited to three or four veneers that least critical and most satisfactory from the standpoi of weight, strength, moisture absorption, etc. Vene are built up in such a way that stress or strain in a direction acts upon the total columnar grain fibers of t veneer layers. Special type of construction is availab to meet radial crushing strength tests and hydrostat internal pressure requirements, as well as for torsio columnar compression, and flexural and tensile strength Plytube is waterproof, flameproof, splinterproof and r proof; has low electrical conductivity, and is dimensio ally stable under extreme temperature ranges which not affect thermosetting adhesives. It is suitable f sub-zero weather, and when coated can be employed carry chemicals and for gasoline and oil containers conduit.



Rotor for Air-Turbine Motors

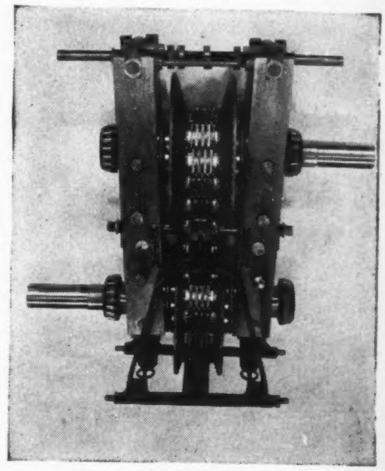


DEVELOPED by Onsrud Machine Works Inc., 3900 Palmer street, Chicago 47, a new rotor has a great deal to do with the useful range of speed and power now available in air-turbine motors. Operating on an impulse reaction principle, the solid milled rotor with bucket-type impeller blades employs an air feed-back system. The expanding air plus the company's patented "metered mist" lubrication hold unavoidable wear to a minimum. These rotors are used on air-turbine motors built by the company, and the complete line includes motors ranging from 1/6-horsepower to 3 horsepower operating at speeds of from 15,000 to 100,000 revolutions per minute. The full line is availabl to machinery manufacturers for incorporating this typ of motor in their units.

Speed-Varying Mechanism

NOW available from Link-Belt Co., 307 North Mich gan avenue, Chicago, is the bare P.I.V. gear speed varying mechanism for integral-designing into machin tools and many other types of machines. The mechanism is furnished without housing, and the engineer can em body it within his machine, running it in the same oi

reservoir with the change gear sets. Operating speed within each speed range is regulated by handwheel or lever. The P.I.V. control shaft is extended just outside the machine housing for mounting of operating lever. Although other media may be used, a gear or silent chain drive is recommended for connecting electric motor to P.I.V. gear input shaft. A speed indicator plate may be attached, for instance, to the front of the gear head of a machine tool, having three rows of markings corresponding to speeds obtained by the P.I.V. gear and three change gear sets. The control lever can be equipped with a



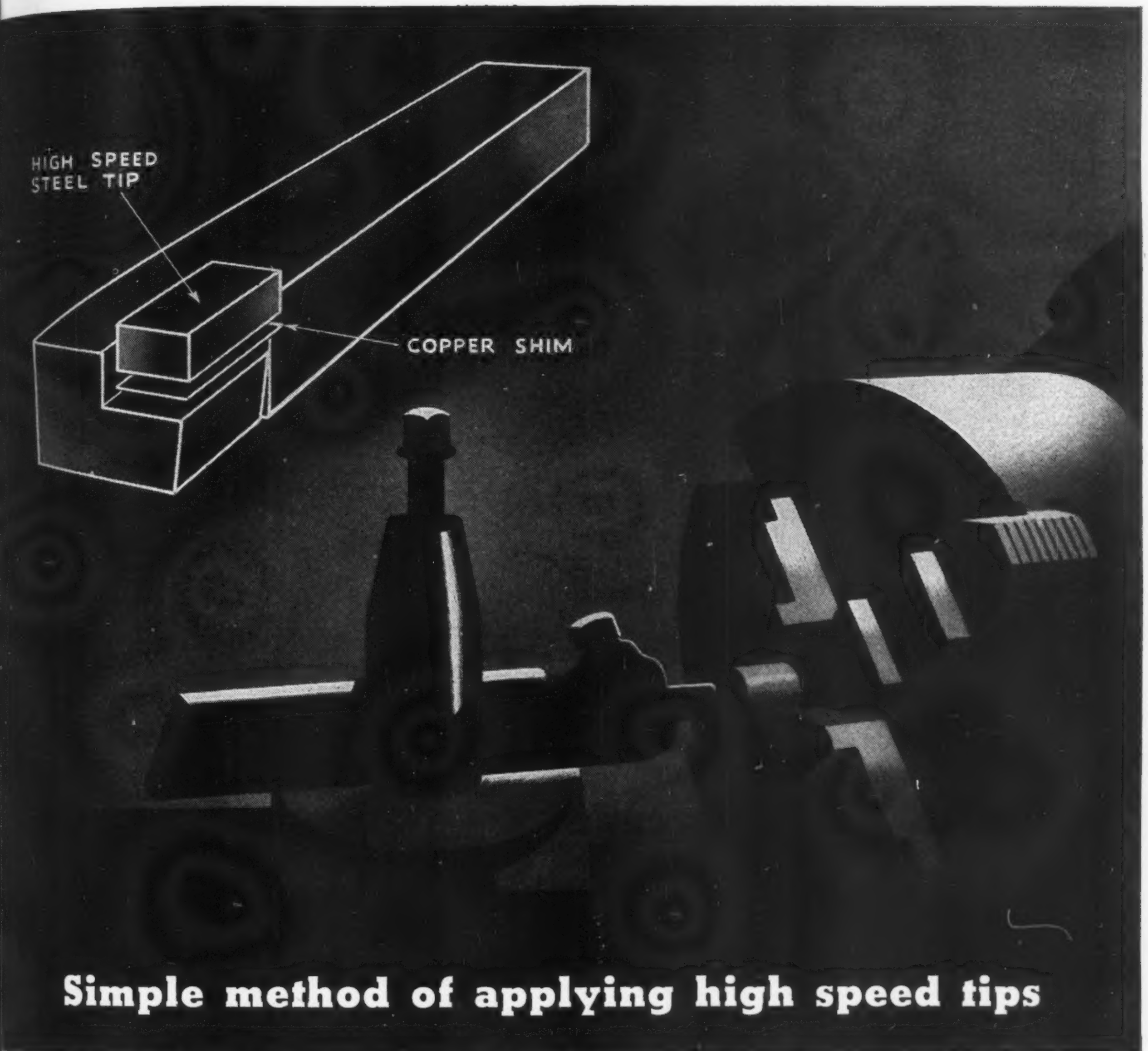
pointer and the scale arranged for vertical motion provided by the change gearshift lever so that the pointer will indicate the speed on the proper scale. Operation is simple since it is necessary only to know the work diameter and cutting speed, select the proper range, shift the control lever until desired speed and diameter coincide, and start the cut. Should speed prove too low or too high, it can be changed without releasing cut. The mechanism is of compact, all-metal construction, employing a positive drive chain making side contact with radial teeth cut on two adjustable-diameter disks constituting each of the two wheels the chain connects.

Synthetic Rubber Available

FOR general purposes a synthetic rubber in three densities is announced by The B. F. Goodrich Co., Akron, O. The three grades are soft, medium and firm, each having good oil-resisting properties. The material can be made into slabs, cord, tubing, or in almost any other molded shape. Slabs 24 x 120 inches are available in thicknesses of 1/8, 3/16, 1/4, 3/8 and 1/2-inch and 24 x 60-inch slabs in 3/4-inch and 1-inch thicknesses. The three grades correspond with prewar crude rubber sponge.

Adjustable Overload Relay

AN ADJUSTABLE overload relay for protection in circuits with varying current demands is the Series 445-G-33393 type announced by Guardian Electric Mfg. Co., 1400 West Chicago boulevard, Chicago. Its out-



Information supplied by an Industrial Publication

Copper brazing offers a readily available means of mounting high speed steel tips on low alloy shanks for cutting tools.

The procedure is quite simple. A recess milled in the shank is thoroughly cleaned and coated with brazing flux. The flux is also applied to the high speed steel tip. A copper shim (0.003 to 0.005 in. thick) is cut to the size of the recess.

The shank is heated until the flux flows freely before the shim is fitted in the recess. After the shim and tip are put in place, the assembly is brought up to 1650° F., in a preheating furnace.

Then the assembly is transferred to a high heat furnace and held at quenching temperature (2200-2350° F.) until the tip is soaked through. Copper melts at 1980° F., therefore the shim will melt and spread over the interfaces, forming a firm bond.

After withdrawal from the furnace the tip is aligned and pressed into place to squeeze out excess copper and flux. As soon as the tip is well bonded to the shank, that end is oil quenched. Final operation consists of the usual high speed steel temper at 1000-1050° F.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

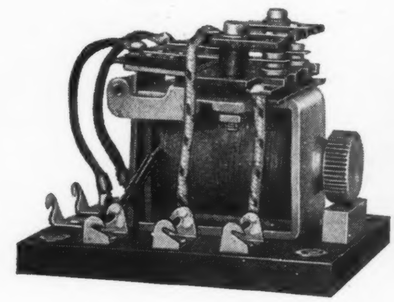
MOLYBDIC OXIDE, BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

Climax Molybdenum Company

500 Fifth Avenue · New York City

MOLY

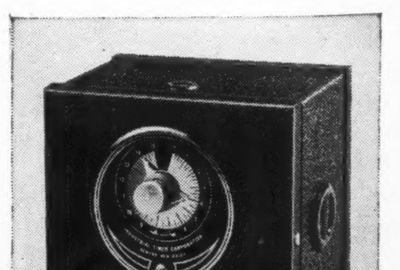
standing characteristic is that it can be adjusted to close at any value from .20 to .75 amps by means of an adjustable core which varies the reluctance of the magnetic circuit. Rating is 5 amps at 115 volts, 60 cycles; up to three-pole double throw. It can be wound to operate on



current or voltage ranges where the minimum wattage is over .32 watts and the maximum wattage is under 4.5 watts. Vibration resistance is 8 times gravity, energized, or de-energized. Dimensions are 1 3/16 x 2 3/8 x 2 7/8 inches; weight, 9 ounces.

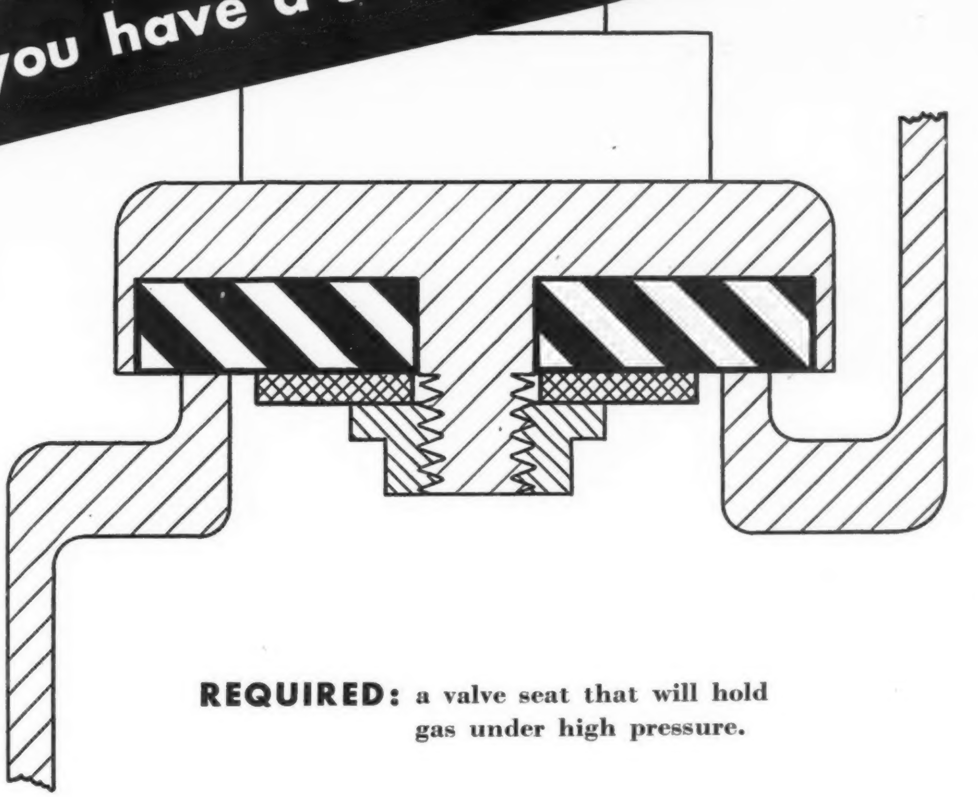
Signalling Timer Announced

DESIGNED for visual and audible attention when a time interval is completed, the new Series S signaling timer of Industrial Timer Corp., 117 Edison Place, Newark, N. J., is versatile in application in that it provides for automatic closing or opening of a circuit at the end of elapsed time, and operates additional buzzers, bells or lights at remote locations. When pointer is set to required interval, a circuit is closed which operates a pilot light indicating that the time interval has started. The moving pointer revolves counterclockwise toward



zero; at any second during the interval exact time elapsed is shown on dial. On completion of interval, an audible alarm sounds and pilot light goes out. The buzzer continues to sound until the toggle switch on the timer is snapped to "off" position or the timing interval is again started by moving the pointer knob to the required interval. Socket on side of timer provides for additional lights or alarms. If closure is required during interval, an easily accessible change-over wire and terminal is provided at the rear of the bakelite case. Rapid resetting

Do you have a sealing problem like this?



REQUIRED: a valve seat that will hold gas under high pressure.

HERE'S THE SOLUTION:

Valve seats made of specialized cork-and-synthetic-rubber compositions, developed by Armstrong, have proved to be the perfect answer to this problem. Selection of the proper composition depends primarily upon the kind of gas handled by the valve.

While the formulas are different, all these Armstrong Compositions have one thing in common: the combination of physical properties necessary to hold gas under high pressure. They are resilient, to form a positive seat . . . and very dense, so as to be impermeable. They do not "freeze" to metal.

ARMSTRONG'S SEALING SERVICE

In addition to cork-and-synthetic-rubber compositions, Armstrong manufactures many other specialized sealing materials. (See the list of general types below.) Compositions with practically any desired combination of physical properties are available as sheet and roll goods, die-cut gaskets, ribbon, tapes, molded shapes, and extruded rings. This wide variety of materials in many forms enables Armstrong to supply the *right* seals for hundreds of types of equipment.

WRITE FOR SAMPLES

For samples of materials which will meet your requirements exactly, send your sealing problems to Armstrong. For helpful data about sealing materials, write for your free copy of "Gaskets, Packings, and Seals." Address Armstrong Cork Company, Industrial Division, 5112 Arch St., Lancaster, Pa.

ARMSTRONG'S

GASKETS · SEALS · PACKINGS

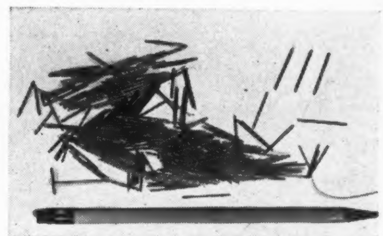
Synthetic Rubbers • Cork-and-Synthetic-Rubber Compositions*
Cork Compositions • Cork-and-Rubber Compositions
Fiber Sheet Packings • Rag Felt Papers • Natural Cork

*FORMERLY "CORPRENE"

of the pointer knob when the same time interval is to be repeated is afforded by an adjustable backstop. Enclosed in a black metal case, the size of the timer is 5 x 5 x 3½ inches. It operates on alternating current, 115-230 volts; 25, 50 or 60 cycles, 1000 watt voltage and frequency to be specified. Motor is slow speed, self-starting synchronous type. Pure silver contacts are used.

Alloy for Small Mechanism Parts

OFFERED in a form adaptable to instrument bearing pivots, needle valves and similar applications, a new alloy of tungsten, chromium and cobalt has been introduced by Haynes Stellite Co., Kokomo, Ind. Resistant to many corrosive media and all normal atmospheric conditions, this stainless metal cannot be machined in small parts; it has to be cast close to size and approximate shape and finished by grinding, and lapping if necessary. Properties of the new material include a tensile strength of approximately 65,000 pounds per square inch, a hardness of rockwell C-60 to C-62, high resistance to



wear, an unusually low coefficient of friction, the ability to take a high polish, and excellent resistance to corrosion, whether from atmospheric conditions or chemical agents, such as water solutions of various salts, alkalies and acids. This nonmagnetic alloy is easily fabricated and can readily be brazed or welded to steel or other base metals, for use in instruments or mechanisms where nonmagnetic, corrosion and wear-resistant parts are essential. Because of its bearing properties the material has been used in other forms to provide wear resistance on various types of industrial equipment. It has also been recommended as a substitute for sapphire bearings. At the present time the alloy is being furnished in many cast forms such as pins for pivots and shafts.

Lubricated Centrifugal Clutch

BECAUSE the new clutch announced by Amalgamated Engineering & Research Corp., 100 West Monroe street, Chicago 3, combines features of both lubricated and centrifugal clutches, is made in all sizes, and can be operated horizontally or vertically with equal efficiency, it has many applications wherever power is transmitted through shafts. This new automatically engaging and self-disengaging centrifugal clutch is produced in an unlimited range of sizes and capacities and serves either as a coupling between shafts or as a driving pulley or gear in a transmission, as well as a starting cushion between power units and driven mechanisms. Known as

RIVERSIDE PHOSPHOR BRONZE

a metal old as time — modern as tomorrow!

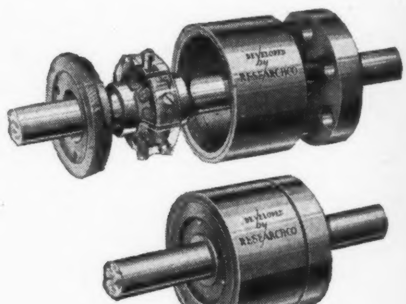
In pre-war days, the quality and uniformity of Riverside Phosphor Bronze was so widely recognized by industry, that this Riverside product became a standard engineering material. Because of prevailing conditions, the entire output of Riverside Phosphor Bronze alloys has now been diverted from many of its normal channels to feed the insatiable appetite of Mars. Thus, Riverside sales representatives, today, do anything but sell; they are expediters, fillers-out of forms, and all-around helpers. As a result, they are often unable to call on as many of our good friends as frequently as we would like. But when the war is won, this Company's sales and technical staff—with a vastly increased amount of experience data to draw upon—will again be at the disposal of industry.

At your service again after Victory V...

THE RIVERSIDE METAL COMPANY

RIVERSIDE... Burlington County... NEW JERSEY
NEW YORK · HARTFORD · CLEVELAND · CHICAGO

the Torkontrol, the unit consists of a partially filled oil chamber fitted with a freely rotating hub which carries a series of movable wedge flyweights. As the hub revolves these weights fly outwardly and engage internal rims of the outer case, binding the hub and shell into a functionally solid pulley or coupling. Working well in either direction, it can be set to engage or release at a given speed, and to slip in case of overload. The sizes in which the clutches are available are from ¼-horsepower to 500 horsepower.



Thermostatic Delay Relay

WITH the new thermostatic delay relay developed by Amperite Co., 561 Broadway, New York, delays from 1 to 100 seconds are claimed to be possible. The relay is compensated for ambient changes of —40 to 100 degrees Fahr., and can be furnished in single-pole, either normally open or normally closed type. Contacts are capable of handling up to 12 amperes, 115 volts alternating current or direct current. Hermetically sealed in an inert gas to assure clean contacts at all times, the unit fits standard octal radio base. Accuracy of electronic timing and extended delays possible with this relay make application possible to processing and industrial machines.

New Synthetic Rubber

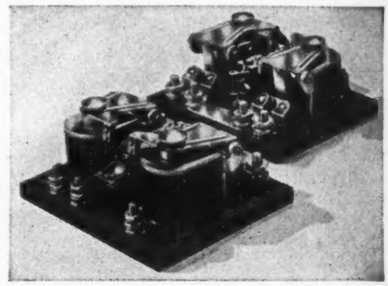
KNOWN as Uskol a new synthetic rubber—the sixth major type to be discovered—has been developed by General Laboratories of United States Rubber Co., 1230 Sixth avenue, New York. This synthetic rubber which will be used in both industrial and household equipment, offers a high degree of resistance to solvents. It can therefore be used in the manufacture of equipment coming into contact with fuels, oils, gasoline, dry cleaning fluids and other penetrating chemicals. Also, it will be utilized for specialties such as industrial molded items, tubing, gas and oil hoses, tank linings, and for application to paper and cardboard to render them resistant

Safeguarding
electrical cables on
this KELLER MACHINE

to grease, water and chemicals. The new synthetic resulted from a search for rubber which would provide greater resistance to attack of high octane aviation gasoline, and its use will be limited to war requirements for the duration.

Dynamic Braking Relay

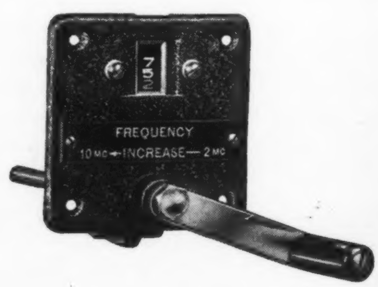
IN THE new types 68HX100 and 67HXX100 relays of Struthers-Dunn Inc., 1321 Arch street, Philadelphia, instantaneous dynamic braking with split-series field motors is provided. The relay offers positive action, less weight and simpler mechanisms for a wide range of aircraft and other applications such as retractable landing gears, wing flaps, trim tabs, bomb bay doors, hoists, and



similar uses utilizing reversing motors. For winch operations, relays permit substitution of a simple locking dog for the conventional large magnetic brake. Of "nutcracker" construction, the lightweight relays have exceptionally strong contact pressure. There are no sliding contacts. Positive contacts select the proper field winding to give reserve torque for braking. Relays operate in all positions and withstand salt-spray, vibration and altitude tests.

Cyclometer-Type Counter

ORIGINALLY designed for registering rotary coil turns, the cyclometer-type counter unit offered by Barker & Williamson, 235 Fairfield avenue, Upper Darby, Pa., has many additional uses such as application where a shaft must be turned a predetermined number of times or set at any predetermined position. The exact number of turns can be recorded on the counter, down to

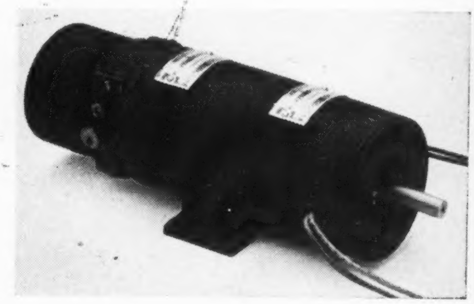


tenths of a turn. Used with rotary coils the counters provide an easy means of setting the contact at any desired inductance value. Other uses range from recording vertical and horizontal stabilizer adjustments on airplanes

to any requirement where a shaft is rotated more than 360 degrees and the exact rotation recorded. The counter assemblies have direct shaft drive (1:1 drive shaft to driven unit). Shafts can be of any length. Units weigh 8 ounces, are sturdy and pass wartime specifications. Available with either right or left-hand rotation, they can be supplied with nameplates to suit the application.

Motor Generator Developed

MODEL L32 motor-generator, recently announced by the Electric Indicator Co., 110 Parker avenue, Stamford, Conn., operates on 6 volts direct-current input (12, 24 or 115 volts direct-current input available). Alternating-current output, 1, 2 or 3 phase, varies with the speed. The standard model is housed in black synthetic-enameled aluminum and includes speed regulator and resistance (speed governor is optional). Speed is controlled within 1 per cent for 25 per cent variation in input or load, and the generator will deliver 27 volts, 2-phase alternating current at 2400 revolutions per minute. The new model is 6¼ inches long, 2 inches in diameter, and weighs 32 ounces. It is base mounted, and is equipped with single 5/16-inch shaft with 1-inch shaft extension.



Coupling Nuts of Sheet Aluminum

AS A result of a new manufacturing development, The Rumsen Co., 8059 Melrose avenue, Los Angeles, is producing its AN conduit, coupling and lock nuts of sheet aluminum. Tests under working conditions, according to the company, have indicated the new conduit nut to be as strong as machined nuts, as well as being light in weight. Critical materials have been conserved in this method of production and also because there is greater availability of aluminum sheet stock over aluminum bar stock. The AN 3054 series of coupling nuts is available in sizes -3, -4, -6, -8, -10, -12 and -16.

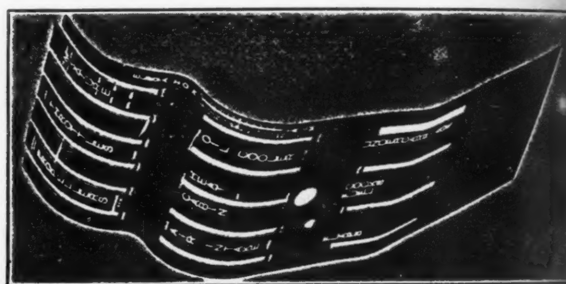
Truck Caster Announced

MADE to withstand the strain of today's high-speed production, Series 600 truck casters produced by Faultless Caster Corp., Evansville, Ind., are furnished with semisteel roller bearing, semisteel plain bearing or Plaskite roller bearing wheels in sizes from 4 to 8 inches in diameter. Load capacities are from 450 to 1500 pounds. Of controlled-analysis alloy of high tensile strength, the

caster has a swivel made with two full rows of hardened balls rolling in separate and uninterrupted raceways. Interlocking lugs securely combine upper and lower raceways as one unit. With this construction, horn of caster is allowed to swivel freely between the two ball bearings.

Curved Panel Moldings

FABRICATION of parts and panels in cylindrical shapes or simple and compound curves at low initial costs for small quantities is possible through a method of plastic molding used by Theodore Moss Co., 33 Flatbush avenue, Brooklyn. Typical of this method is the airplane panel which is accurately machined to accommodate levers and knobs, and conforms rigidly to number of



curves specified by the designer. It measures 27 inches long by 7¾ inches wide and bears data in depressed white enameled letters, legible due to their color contrast with the black panels. The panel is first molded flat and, while suspended in a semi-cured state, yields to curves of an inexpensively built forming device. The plastic panels are lighter than aluminum and much lighter than other metals.

Multiple Lubrication System

REGARDLESS of location or condition of bearings, positive lubrication on machine tools and similar equipment is assured by the improved Multival lubrication system made by Farval Corp., 3249 East Eightieth street, Cleveland. Under pressure, oil or grease is delivered to the distributing blocks by means of a manual or power-operated gun serving as a central pump. Complete equipment consists of multiple valve blocks, each serving two to ten bearings, lubricant lines leading to individual points, and suitable fittings to accommodate any type of bearing connection. Each measuring valve can be individually adjusted to deliver the exact amount of lubricant required by the bearings it serves. With blocks mounted at accessible points on the machine all bearings can be lubricated while equipment is in full operation.

Slide Chart for Threads

SHOWING United States Standard dimensions for coarse and fine thread series a slide chart has been issued by The Elemoto Sales Co., Teaneck, N. J. When slide inside the housing is moved to the right or left, the

standard dimensions for each size from No. 0 to 1¼ inches are placed at the windows in the blueprint dimension drawings. All required dimensions such as threads per inch, major and minor diameters, head sizes, etc., are instantly obtainable with one reading. Decimal equivalents of fractions and a useful table of United States Standard Gages for Steel Sheets are given. The reverse side of the slide is used to obtain dimensions for U. S. Standard (and other commercial sizes) Woodruff Keys. The lower section is used to determine dimensions for American Standard pipe threads. New features of the slide chart are: Two-color slide; water-resistant and washable surface; improved construction; and data revised to correspond with latest government standards.

Flexible Fastener for Hose

TO MEET the need for a simplified strap that will eliminate the whip of hose in airplane engines, Packless Metal Products Corp., New Rochelle, N. Y., has introduced its flexible fastener which has the combined function of a supporting strap and a vibration absorber for stationary or movable tubing. The fastening consists of a spring, cone-spiraled and terminating in a clip which snaps on to the tube or similar unit to be fastened. Chosen to fit the outside diameter, the fastener is affixed to a supporting surface by means of standard or wood screw

fitted through the cone. Inasmuch as it flexes in all directions it can be installed in either lateral or vertical position. When used to support flexible hose, it prevents whip and counteracts "frequency" set up in the flexible tubing. On copper tubing the fastener's free action prevents fatigue failure. On corners the fasteners may be systematically set so many inches apart to prevent tubing bends from making abrading contact. Upon any impact the fastener compresses into its cone, cushioning the hose against injury. While designed originally for aircraft use, it is well adapted to application in the railway, refrigeration and other fields.

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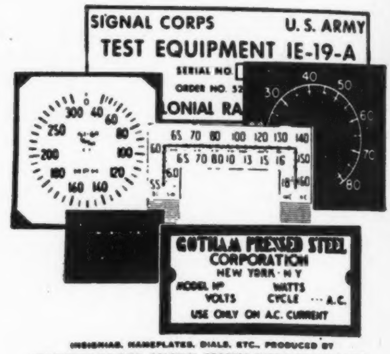

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wear, weather and acid resistance. In addition to complete service, the company will supply the screens directly to manufacturers wishing to handle marking in their own plants. These screens can be used without special machinery and are supplied with necessary instructions. They can be made up from any copy, large or small.

Blind Rivet Can Be Inspected

HAVING the simplicity of a common screw and nut, the new blind fastening of Pacific Railway Equipment Co., 960 East Sixty-first street, Los Angeles, is applicable in almost any place where riveting is used, particularly for blind riveting. No special tools for installation are necessary; the rivet is inserted and tightened with an ordinary hand ratchet or power screw driver. It is unaffected by heat or cold, or sudden changes in temperature. The new fastening is a combination of three parts, a steel cadmium-plated recessed head screw inserted into the hollow stem of a high-strength aluminum alloy rivet, and a knurled nut of Dural threaded on the end of the screw. Both rivet sleeve and nut are anodized. The nut has a positive self-locking action—sheets are gripped tightly together and the expansion of the rivet sleeve fills the hole completely. According to the manufacturer, this blind rivet when installed can be test-inspected. Two types of screws are available, the "raised" head and the "flush" head types, each in three diameters.

Engineering Dept. Equipment

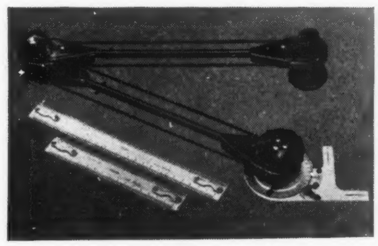
Blueprint Protection Improved

MOISTUREPROOF, dirtproof and greaseproof, a new thin, flexible, transparent film covering offered by Arthur Brown & Brother, 67 West Forty-fourth street, New York, adheres instantly to any surface, forming a

protective covering for maps, charts, blueprints, tracings and other papers constantly handled in drafting rooms. Known as Presto-Seal, it is furnished in rolls. After being cut to the desired size it can be applied by stripping off the backing and pressing down firmly on the surface to be covered. Pencil, ink, crayon or typewriter can be used to write on the surface, and can be erased or wiped off with a damp cloth when it has served its purpose. Repairs on torn tracings, maps or drawings can also be made. The covering has proved helpful on the battlefield where campaign maps are continuously handled under most adverse conditions as it can withstand constant folding and refolding and is able to resist ravages of dust, sand and moisture.

Small Flexible Drafting Machine

KNOWN as the Junior Drafter, a new small drafting machine announced by V & E Mfg. Co., Pasadena, Calif., can be mounted on a portable board. Through use of the new shock-resisting plastics it combines light weight (3 pounds) with advantages found in large drafting units. Some of the features of the new machine are accurate,



parallel motion over the entire board; a full circle baseline setting; prelubricated and double-sealed ball bearings; and enclosed pulleys. Disk brakes at anchor and elbow permit the unit to be used on steeply inclined boards. Being of plastic, the central skid button will not mar the paper. Lightweight aluminum scales are available in 8 and 12-inch lengths and fit into resilient, slotted chucks in the scale holder. Protractor is 3¾ inches in diameter. The drafter is flexible so that scales lie flat, and the head can readily be raised high off the board.

Four Degrees of Tracing Pencils

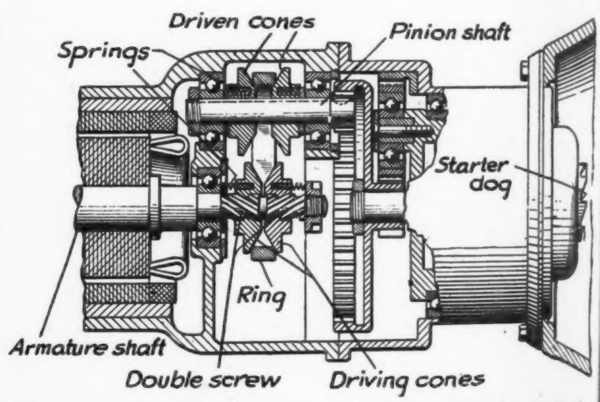
TRACING pencils in grades 1, 2, 3 and 4 have been added to the line of Kim-ber-ly pencils produced by General Pencil Co., 67 Fleet street, Jersey City 6, N. J. These four degrees of tracing pencils were made to fulfill a need for the making of blueprints from original pencil drawings on tracing paper, eliminating inking of drawings. No. 1 tracing pencil may be used for heavy bold-faced lettering and outside borders; No. 2 and No. 3 are the degrees to be used for the drawing itself. Best results are obtained by using a chisel point and going back over the line, making a sharp line of great opacity which will produce a white line with no "ghost" on the finished blueprint. The No. 4 tracing pencil is used only for shading areas.

Noteworthy Patents

Self-Adjusting Variable-Speed Drive

INFINITELY variable speed control which functions automatically in accordance with the load, as applied to the design of engine starting mechanisms, is covered by patent 2,330,136 assigned to Bendix Aviation Corp.

In the airplane type of starter such as shown in the drawing, it is desirable that the gear ratio be varied in accordance with torque requirements. With the form of transmission hitherto used between the constant-speed driving unit and the engine-engaging member, the gear ratio cannot be changed during the cycle of operation. Consequently, if the engine offers resistance to being



High torque at starting causes driving cones to separate, resulting in speed reduction between armature and pinion shafts. Low torque permits driving cones to close up

turned over at the predetermined cranking speed, there is necessarily slippage at the point where the slippage clutch is installed, with resulting energy loss.

As shown in the drawing, the design includes a double screw, formed on the extension of the armature shaft. These screws engage corresponding threads on driving cones. Torque transmitted from armature shaft through the double screw to the cones acts to compress springs and separate the cones, the degree of separation depending on the torque value. Splined to the pinion shaft are two driven cones pressed together against the driving ring by springs. Springs on the driving cone are considerably stronger than those on the driven cone hence, when not in operation, the driving cones are closed up and the driven cones are open. A step-up ratio between the armature shaft and the pinion shaft therefore results. This condition is obtained at light torque loads.

As the torque increases, the reaction between the double screw and the driving cones separates the cones and drops the driving ring deeper between the cones. The driven cones simultaneously close up to absorb the

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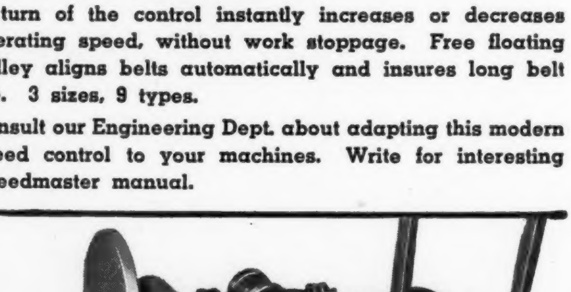


slack on the ring, proper contact pressure being maintained by the springs on the driven cones. The ratio now changes so that the pinion shaft rotates at a relatively lower speed than the armature shaft, then adjusts itself in accordance with the torque on the motor.

In operation, the motor is energized and the engine-engaging jaw clutch element or starter dog advances to engage with the engine jaw, located in the engine housing to which the starter housing is attached. A high torque is required to break the engine loose and accelerate it. Driving pulley cones immediately separate to increase the ratio between motor and jaw. As soon as the engine has been accelerated, the torque required to keep it turning over is reduced and this reduction is transmitted back to the motor. Under the reduced torque the springs on the driving cones overcome the separating force of the screw shaft and the cones are forced closer together, thereby decreasing the ratio between motor and jaw and increasing the speed of the jaw. The motor may therefore be caused to operate at practically constant torque and at a point of maximum efficiency.

All-Hydraulic Valve Mechanism

Hydraulic operation of intake and exhaust valves of internal combustion engines provides a mechanism which occupies less bulk than conventional pushrod-opened and spring-closed types. Covered by patent 2,329,662, recently assigned to Wright Aeronautical Corp., the design includes a hydraulic impulse generator which opens the valve against a constant hydraulic closing force, and a valving system by which a continual flow of hydraulic fluid is maintained through the system, leakage being returned to the hydraulic fluid supply.

As figure on Page 208 shows, a reciprocating cam follower is provided with a roller engaging with an engine cam having a lobe. Upper end of the cam follower is formed as a piston fitted to a cylinder, the whole constituting a hydraulic impulse generator. Space above the piston is supplied with hydraulic fluid from a conduit through a check valve, the conduit being connected to the output of a pressure pump supplied from a reservoir. A pressure-relief valve bridges the pump to maintain a substantially constant pump outlet pressure.

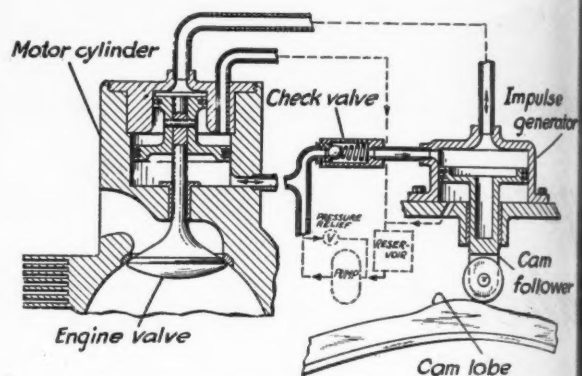
Space above the piston communicates through a pipe with the top of the motor cylinder which is provided with a differential piston. Lower side of the large piston communicates with the pump output conduit, while the space between the pistons is vented to the reservoir. Since pump pressure is imposed continually within the cylinder under the large piston, valve closing force is continuous and is proportional to the area of the piston and the pump delivery pressure. Because of the check valve, the cylinder of the impulse generator as well as the space above the small piston in the motor cylinder and also the connecting pipe are maintained full of oil at all times under pump pressure. When the cam lobe raises the cam follower, the pressure in the space above the piston of the impulse generator is raised well above pump pressure, the hydraulic fluid being prevented from escape by the check valve. This pressure rise acts upon

(Continued on Page 208)

(*Continued from Page* 202)

the top of the differential piston, opening the valve against the constantly exerted closing pressure on the underside of the large piston. As the valve opens, fluid in the cylinder must back up and escape from the piston through the pressure relief valve. As soon as the cam follower passes the cam lobe, the valve-opening pressure is relieved and immediately the valve is closed by pressure upon the lower side of the differential piston. Any leakage past the piston runs to the reservoir.

In practice, the hydraulic fluid pressure will be derived from the oil-supply pump of the engine, which usually delivers oil at a pressure of the order of one hundred pounds per square inch. Assuming such pressure as an



Engine valve normally is held closed by pump pressure below differential piston. Hydraulic impulse due to cam follower passing over lobe acts on top of differential piston and opens valve

example, the net cross-sectional area of the motor cylinder would be around 3½ square inches to secure a valve closing force of 350 pounds, which is typical for a large aircraft engine. The valve opening force is considerably in excess of this value and is derived from the positive displacement of the cam follower piston and the small valve piston of the differential piston. The area ratio between the cam follower piston and the smaller end of the differential piston is chosen in accordance with the height of the cam lobe and the valve lift needed. The valve lift may be greater or less than the cam lobe height accordingly as the cam follower piston is greater or less than the smaller end of the differential piston.

Safety Governor for Pneumatic Tools

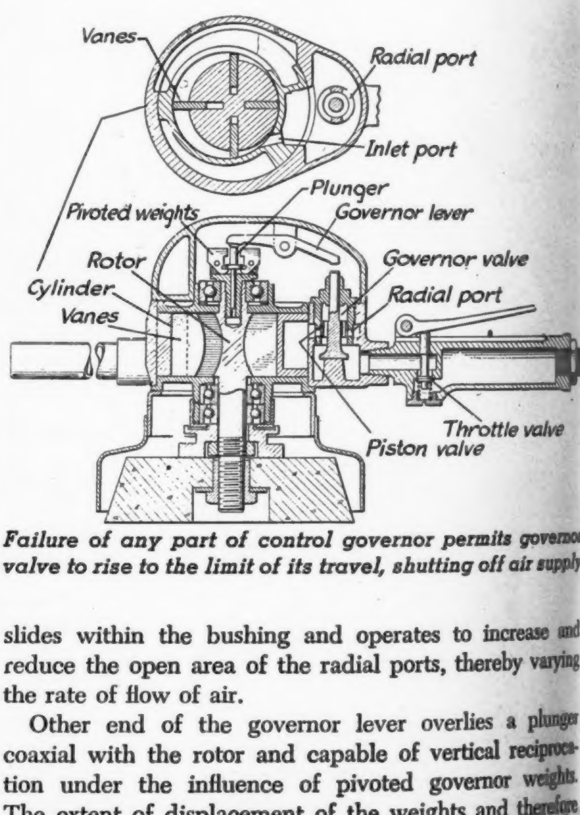
AN EMERGENCY speed control for pneumatic tools which completely shuts off the air supply in the event of failure of the main speed governor is covered by patent 2,326,396, recently assigned to Chicago Pneumatic Tool Co. Employing a control valve with a primary head in the form of a piston valve, for speed regulation, and a secondary head functioning as a poppet valve, for emergency shut-off, the design also eliminates the use of springs in the governor mechanism.

In the figure, the safety governor is shown incorporated in a portable grinder of the vertical type. The motor is of the rotary type, having a rotor and vane eccentrically mounted in a cylinder. Air enters through the inlet ports

shown in the plan view and leaves through an exit port, diametrically opposite the inlet.

Compressed air is supplied through the right-hand handle which contains a throttle valve under the control of the operator. In the illustration the parts are shown in the positions they assume with the air shut off at its point of entrance to the tool. The governor valve is in its lowest position, resting against an abutment.

When the throttle valve is opened, compressed air is admitted to the underside of the governor valve. As a result, the governor valve rises until it abuts the end of the governor lever. In this position the piston valve is open, admitting air through the radial ports to the inlet port of the motor. The valve is mounted in a bushing and comprises a circular head portion or piston valve and a stem portion operating in a guide, while the lower end is in the form of a poppet valve. The piston valve



Failure of any part of control governor permits governor valve to rise to the limit of its travel, shutting off air supply

slides within the bushing and operates to increase and reduce the open area of the radial ports, thereby varying the rate of flow of air.

Other end of the governor lever overlies a plunger coaxial with the rotor and capable of vertical reciprocation under the influence of pivoted governor weights. The extent of displacement of the weights and therefore of the plunger is, of course, determined by the speed of operation. The motor speed is, in turn, controlled by the load and tends to increase sharply when the tool is lifted from the work. Upper end of the plunger normally is in contact with the adjacent arm of the governor lever, and turns the lever in a clockwise direction as the motor speed increases, permitting it to return in the opposite direction as the motor speed decreases. Movement of the governor valve toward closed position is resisted by the pressure of the air.

Governor valve normally is controlled in its upward motion by the governor lever but has an extreme limit of movement in that direction, set by the engagement of the auxiliary poppet head with the lower end of the piston valve bushing. The effect of such engagement is to close off the supply of air to the motor. By this means increased safety of operation is obtained since, should breakage occur, the motor will be promptly stopped.

ASSETS to a BOOKCASE

Aircraft Hydraulics

By Harold W. Adams, chief of mechanical and equipment section, Douglas Aircraft Co., Inc.; published by McGraw-Hill Book Co., 159 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$1.75 postpaid.*

Emphasizing the underlying principles applying to hydraulic systems rather than the details of currently employed systems, this treatise presents technical data pertaining to hydraulic pumps, lines and motors.

Light weight, controllability and low inertia of moving parts, the chief advantages of the hydraulic form of power transmission over other systems, are pointed out along with precautions concerning inherent limitations.

Immediately following an introductory chapter dealing with fundamental concepts of the operation of units such as reservoirs, hand pumps, gear pumps, operating cylinders and plug, slide and poppet valves, a thorough discussion on fluid flow covers the determination of laminar and turbulent flow, viscosity, Reynolds number, friction factor, head loss, and discharge through various orifices. Subsequent chapters trace the development of modern hydraulic systems, explain the variety of systems now employed in aircraft and give the design requirements of systems and subsystems.

Of particular significance for designers will be the sections devoted to design procedure as applying to the major units as well as to the complete systems. Final chapters deal with manufacture of aircraft hydraulic units, installation of systems, testing of units and system maintenance.

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Engineering Mechanics

By Ferdinand L. Singer, assistant professor of engineering mechanics, New York University; published by Harper & Bros., New York; 482 pages, 6⅛ by 9¼ inches, clothbound; available through MACHINE DESIGN, *$4 postpaid.*

Clearly conveying information on a complex engineering subject by means of the written word is seldom an easy task. It would seem the most practical method is that which gives the reader a mental picture of what is being discussed—a graphic visualization of the applying principles.

Here is a book which commendably employs just such an approach. The author has made a sincere effort to present his subject in a manner which assures ready and complete comprehension of the principles involved.

Although emphasis is placed on analytical methods, graphic presentation is also utilized and with particularly

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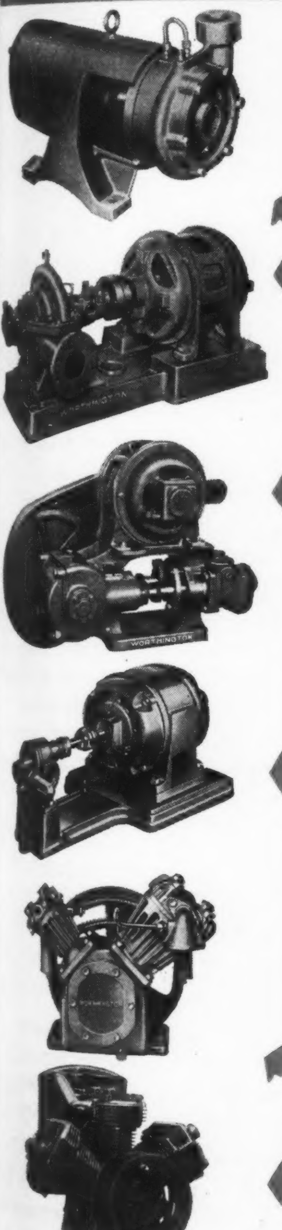

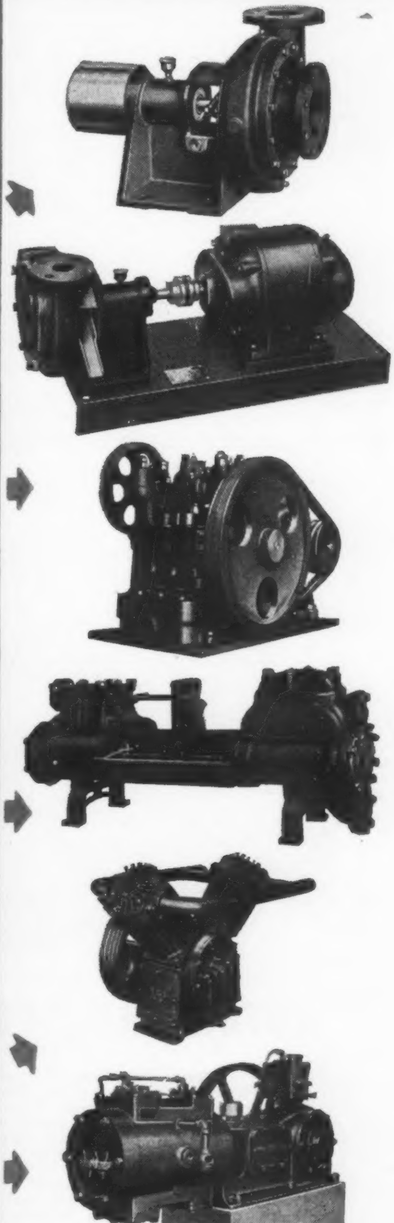

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good effect in Part II which deals with dynamics. Simplified treatment is accorded such phases of the subject as: Force systems in space; Mohr's circle to determine maximum and minimum moments of inertia; velocities and accelerations in plane motion; dynamic equilibrium; work-energy and impulse-momentum methods.

Two major sections: Statics and Dynamics, are subdivided into chapters on basic principles, resultants and equilibrium of force systems, analysis of structures, friction, centroids and centers of gravity, moments of inertia, rectilinear and curvilinear translation, rotation, work and energy, mechanical vibrations, etc.

□ □ □

Lubrication of Industrial and Marine Machinery

By William Gordon Forbes; published by John Wiley & Sons, Inc., New York; 319 *pages,* 5⅜ *by* 8⅜ *inches, clothbound; available through* MACHINE DESIGN, $3.50 *postpaid.*

Covering all pertinent aspects of the subject matter, this book presents data which is based largely on practical experience rather than pure theory.

To give the reader a thorough comprehension of lubrication engineering's many phases, the author has devoted his early chapters to the fundamentals of distillation, cracking, refining, and petroleum chemistry. These preliminary discussions deal with "topping" operations as they occur in fractionating towers, classification of mineral oils, atomic structure of petroleum products, thermal and catalytic cracking, refining, filtration, blending, etc.

Of more immediate interest than the foregoing to the machine designer will be the discussions devoted to bearing lubrication, the formation of oil films, influence of oil grooves in bearings, and data on bearing metals. In addition, practical data is supplied on a variety of methods for applying lubricants and specific recommendations are offered for lubrication of ball and roller bearings as well as for many types of engines and machines. The final chapters, on greases and their application, should prove of considerable interest.

□ □ □

Airplane Hydraulic Systems

By Hugh C. Aument Jr., instructor at Roosevelt Aviation School, New York; published by The Ronald Press Co., New York; 120 *pages,* 5½ *by* 8¼ *inches, clothbound; available through* MACHINE DESIGN, $2.25 *postpaid.*

Dealing specifically with the operation of aircraft hydraulic systems such as those used to actuate retractable landing gear, flaps, tail wheels, bomb doors, gun turrets, etc., this slim volume should prove a handy ready reference not only for aircraft maintenance mechanics but also for design engineers not actively engaged in the application of hydraulics. The various system illustrations, along with their nontechnical descriptions, provide a refreshing source of background interest.

HYDRAULIC LINES . . . .

(*Continued from Page* 149)

length of pipe, continue tracing along line which slopes slightly down toward right to the scale so marked.

It should be noted that some of the pipe-size lines which slope down toward right from top line of chart are dotted. If one of these is used it is necessary to multiply the final result by 100. In any case, since the pressure drops are given per foot of length, they must be multiplied by the number of feet in the line.

It would be feasible to assume that, in a given problem, conditions of flow, line size, etc., might exist which are not covered by the chart. In such cases the head loss can be determined by calculation. For check purposes, the problem handled in the chart will be worked out.

This problem requires determination of the pressure loss per foot through a tube 1 inch O.D. by .049-inch wall (.902 I.D.). The fluid used is assumed to be Lockheed 5 at 50 degrees Fahr., flowing at a rate of ten gallons per minute. S.S.U. for this fluid is about 340.

Formula for head loss is

$$h=f\frac{V^2L}{2gd}$$

In which h = head loss, feet of fluid
f = friction factor
V = velocity, feet per second
L = length of pipe, feet
d = inside diameter of pipe, feet
g = acceleration of gravity, 32.2 feet per second²

To use the above formula, value of f, which is dependent on the type of flow existing in the line must be known. Type of flow (laminar or turbulent) is in turn dependent on R, the Reynolds number. (Formula given later).

Calculating Procedure

1—Determine the Reynolds number. If it is less than 2000, type of flow is assumed to be laminar. If it is greater than 2000, flow is assumed turbulent.

2—Determine f.

For laminar flow the formula is

$$f=\frac{64}{R}$$

For turbulent flow the formula is

$$f=.0056+\frac{500}{R^{.32}}$$

3—Calculate head loss.

The formula for determining Reynolds number is:

$$R=\frac{Vd\rho}{\mu}$$

in which V = velocity in centimeters per second, d = inside diameter of pipe in centimeters, ρ = density in grams per cubic centimeter, μ = absolute viscosity in

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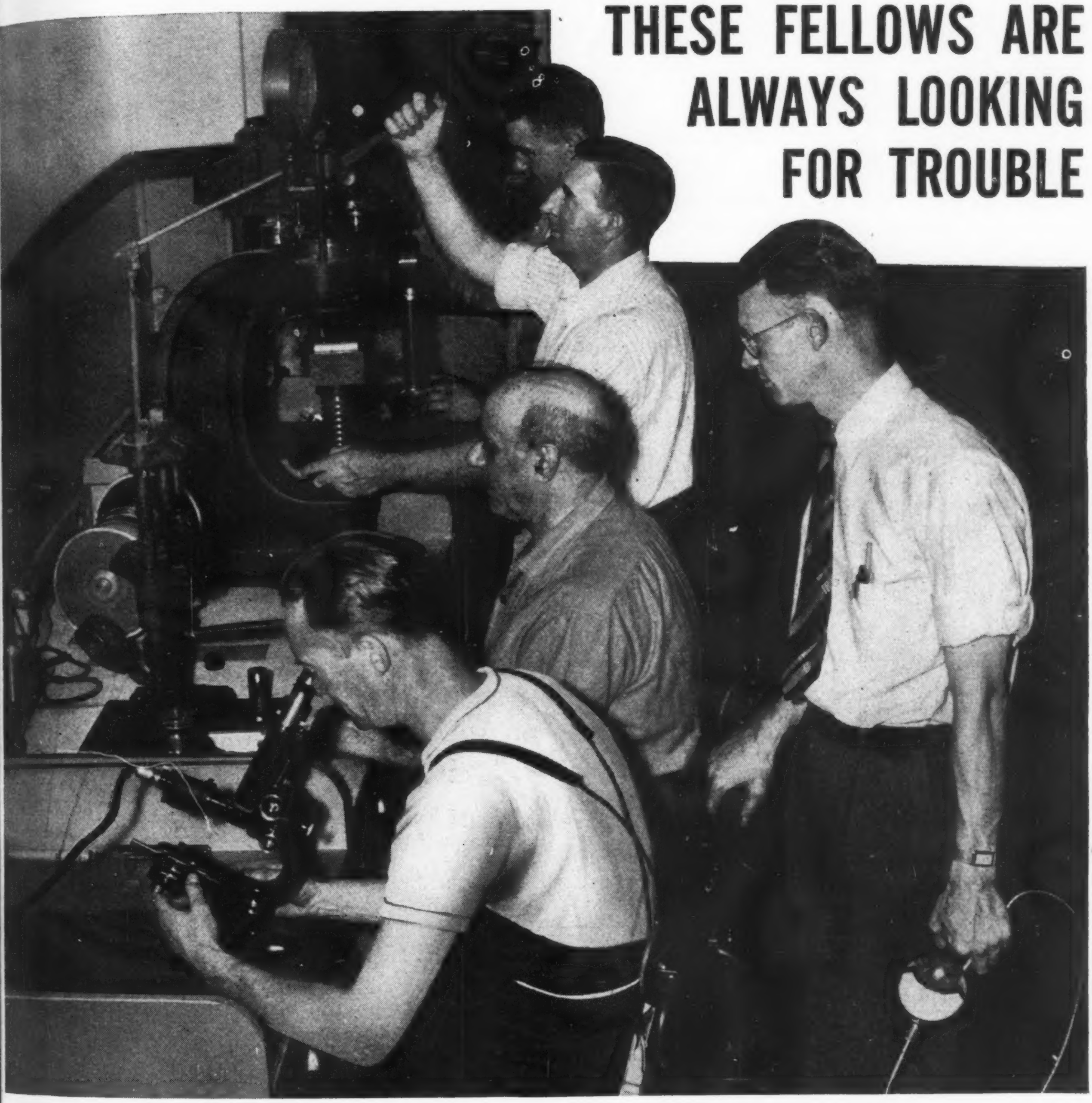

—so they can prevent it! They're the "watch dogs" of our Heat Treating Processes, where good bearings get off to a good start. Theirs is a roving commission, *re*-checking the checking done by the regular inspectors—to make doubly sure each step of the Heat Treatment of Hyatt Roller Bearings produces perfect results.

'Round the clock, 'round the year, they're on the job, looking for trouble—to save *you* trouble. They've worked out a series of continuing tests covering every phase of Heat Treatment. Some are repeated every 15 minutes, others several times an hour—some take only several seconds, others several hours. All are important...as is every test in precision bearing manufacture.

So important, in fact, that one out of every 6 Hyatt employes devotes his time to testing and inspection in various stages of manufacture.

Sound like a lot of work? It is—but worth it when you remember that more than 90% of all Hyatt Roller Bearings made today go directly into fighting equipment or the machinery that helps build it.

That's why we've *got* to make 'em good. Because Victory is our Business.

Hyatt Bearings Division of GENERAL MOTORS CORPORATION, Harrison, N. J.

Pave the Road to Victory with War Bonds

HYATT BEARINGS DIVISION OF GENERAL MOTORS

poises.

$$V = \frac{\text{gal per min} \times \text{cu cm/gal}}{\text{pipe area in sq cm} \times 60}$$

$$= \frac{10 \times 3{,}786}{\pi(.451 \times 2.54)^2 \times 60} = 153.5 \text{ cm/sec} = 5.03 \text{ fps}$$

$$d = .902 \times 2.54 = 2.29 \text{ cm} = .0752 \text{ ft}$$

$$\rho = 1 \text{ (water, gm/cu cm)} \times .96 \text{ (specific gravity)}$$

$$= .96 \text{ gm/cu cm}$$

To determine μ, use the formula:

$$\mu = \nu\rho$$

in which ν = kinematic viscosity in stokes, determined by one of the formulas:

when $32 < t < 100$, $\nu = .00226t - 1.95/t$
when $t > 100$, $\nu = .00220t - 1.35/t$

in which t = Saybolt Seconds Universal (S.S.U.). Since S.S.U. is 340, $\nu = .0022 \times 340 - (1.35/340)$
$= .744$ stokes

Then $\mu = .744 \times .96 = .714$ poise.

Thus $$R = \frac{Vd\rho}{\mu} = \frac{153.5 \times 2.29 \times .96}{.714} = 473$$

Determining Friction Factor

As R is under 2000, the flow is laminar and for determining f we use formula:

$$f = \frac{64}{R} = \frac{64}{473} = .135$$

Calculating Head Loss

All values occurring in the formula having been determined, the head loss is calculated:

$$h = f\frac{V^2L}{2gd} = \frac{.135 \times 5.03^2 \times 1}{.0752 \times 64.4} = .71 \text{ ft per ft run}$$

This figure checks closely with the charted result of .73 ft. per ft. run.

Flexible Lines

There are many applications of hydraulics where the units requiring interconnection must be free to move relative to each other. In aircraft, for example, hydraulic brakes are employed on the retractable landing wheels. Again, actuation of wing flaps, bomb doors, retracting struts, etc., is accomplished hydraulically. Similarly, in many machines utilizing hydraulics for power and control, relative movement between units predicates the use of flexible lines.

Reinforced synthetic rubber hose is used extensively for such applications and is procurable in three general classifications: Low pressure, medium pressure and high pressure.

Low pressure hose consists of an inner tube compounded of synthetic rubber, reinforced with a single braid of cot-

ton, with or without an outer layer of synthetic rubber. (See *Fig.* 6)

Medium pressure hose consists of an inner tube compounded of synthetic rubber but, instead of being reinforced with only one braid of cotton, it employs two or three and it may or may not utilize an outer layer of synthetic rubber. This two-braid reinforced type, with outer layer of synthetic rubber, is shown in *Fig.* 7. The three-braid type, without synthetic rubber outer layer, is pictured in *Fig.* 8.

High pressure hose consists of the same synthetic rubber inner tube as is used in the low and medium pressure types, but the reinforcement is a combination of cotton and wire braids embedded in a bonding material. Its outside cover may be either a layer of synthetic rubber or an additional cotton braid. Hose illustrated in *Fig.* 9 has synthetic rubber outer layer.

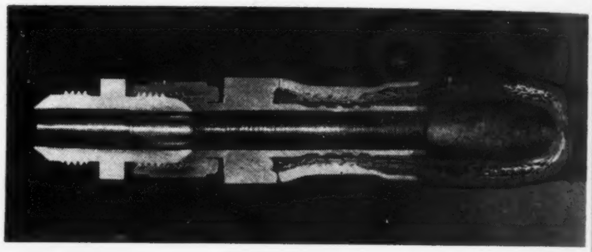

Fig. 9—High pressure flexible synthetic rubber hose with cotton and wire braid reinforcement and outer layer of synthetic rubber

All these types of flexible hose owe their bursting strength to the reinforcing braid which envelops the inner tube. While they are all flexible, the high pressure type will not flex as much as the low and medium.

Operating conditions under which these types of hose will perform satisfactorily are in many cases extremely severe. For example, to comply with standard Army-Navy Aeronautical (A-N) specifications, they must:

1. Be oil and gasoline resistant inside and out
2. Withstand severe vibration and flexing
3. Be unaffected by cleaning solvent externally
4. Stand whipping in slip stream (aircraft applications)
5. Resist flying pebbles (aircraft applications)
6. Endure temperatures up to 160 degrees Fahr.

Data on Standard Synthetic Rubber Flexible Hose

Nominal I.D. (inches)	Max. O.D. (inches)	Working Pressure Max. (psi)	Proof Test Pressure (psi)	Burst Pressure Min. (psi)	Min. Bend Radii (inches)	Weight (lb. per ft)
LOW PRESSURE TYPE						
⅛	.358	415	1250	2500	3	.06
3/16	.420	333	1000	2000	4	.075
¼	.490	275	750	1500	5	.08
⅜	.625	165	500	1000	6	.11
MEDIUM PRESSURE TYPE						
⅛	.500	975	2900	5800	5	.08
3/16	.625	835	2500	5000	6	.12
¼	.720	835	2500	5000	6.5	.13
5/16	.780	800	2500	4800	7	.19
⅜	.875	800	2500	4500	8	.22
½	1.032	500	1500	3000	9	.35
HIGH PRESSURE TYPE						
3/16	.656	3600	9000	18000	6.5	.28
¼	.718	3600	9000	18000	7.5	.31
5/16	.843	3000	7500	15000	8	.40
⅜	.906	3000	7500	15000	9	.50
½	1.031	2400	6000	12000	10	.60

Sizes and various pertinent properties applying to the low, medium and high pressure types are listed in the accompanying table, "Data on Standard Synthetic Rubber Flexible Hose." Since sizes larger than ½-inch inside diameter are seldom used in machinery hydraulics, they

are not listed.

Proof test pressure, the heading of Column 4 in the table, indicates the pressure at which the hose assemblies, complete with end fittings, are tested by the producer before shipment from the factory. In addition to this particular test, however, many breakdown tests are continuously being made by hose and hose assembly manufacturers. One of these tests, illustrated in *Fig.* 2, subjects the hose to continuous flexing. Six hoses are tested simultaneously. The two disks, with their connecting bar, rotate at 800 revolutions per minute, carrying the hose ends, which are coupled to the bar, through eight-inch diameter circles. The opposite ends of the hoses are coupled to fixed blocks through which hydraulic fluid, under pressure, enters each hose. This test is pursued

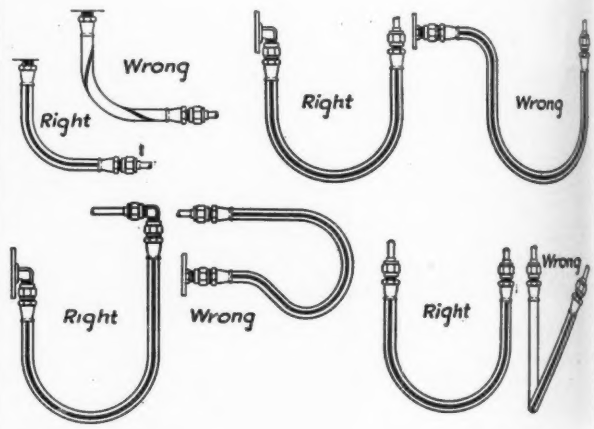

Fig. 10—Right and wrong ways to install flexible hose

through many thousands of cycles until the hoses actually give way.

When laying out the paths for flexible hose, a few general precautions, based on practical experience in the field, should be heeded. Right and wrong methods of installation are pictured in *Fig.* 10. All these drawings serve to emphasize the desirability of keeping the hose free of unnecessary strains such as would be imposed by twisting or needlessly sharp bends.

Other Types of Lines

Much progress is being made with rigid metal tubing of welded construction and undoubtedly its use will continue to broaden in the hydraulics field. In the flexible field, plastic tubing and fittings are showing increasing possibilities, although at the present time their use is limited to relatively low pressures and temperatures. However, the general rules given throughout this article apply also to these types.

MACHINE DESIGN is pleased to acknowledge the cooperation of the following companies in the preparation of this article: Aluminum Co. of America; John S. Barnes Corp. (*Fig.* 1); Calumet & Hecla Consolidated Copper Co., Wolverine Tube Div. (*Fig.* 3); J. N. Fauver Co. Inc.; The B. F. Goodrich Co.; Hydro Power Systems Inc.; National Tube Co.; The Parker Appliance Co.; United States Rubber Co.; Vickers Inc. (*Fig.* 4). The generous assistance of the Weatherhead Co. (*Figs.* 2, 6, 7, 8, 9 and 10) is particularly appreciated.


PROBLEMS THAT COME TO
Gilmer
WILL A RUBBER BELT LAST WHEN EXPOSED TO OIL?
Under the present government program, most rubber products are being converted from crude rubber to synthetic rubber. All synthetic rubber is not oil-resistant. But, Gilmer engineers and chemists developed a synthetic oil-resistant compound and put it on the market 12 years ago. You can have any multiple V-belt, Flat belt, or Round belt with this special construction to combat excess oil conditions. Remember: GILMER OIL-RESISTANT BELTS.
CAN YOU RUN A RUBBER BELT IN HEAT THAT WOULD FRY AN EGG?
Most Gilmer Belts can be supplied in a special heat-resisting quality. These specialized products are built to run in temperatures up to 300°F., when such temperatures are intermittently present. The belts are designed to give life-time service in steady temperatures up to 200°F., or 75°F. above the temperature test of normal belting. Remember: GILMER HEAT-RESISTANT BELTS.
CAN STATIC DISCHARGE BE CONTROLLED?
The special static dissipating features developed by Gilmer engineers has been approved by Fire Underwriters and is available in any standard Gilmer Belt, with the exception of textile-woven Speedages. It drains static continuously through the pulleys and does away with the costly static dissipating devices. Remember: GILMER STATIC DISSIPATING BELTS.
WHAT ABOUT STRETCH CONTROL?
To prevent excessive stretch, Gilmer V-Belts are constructed with normalized cords . . . cords that have been worked to prevent subsequent shrink and stretch. This gentle "working" does not injure the strands of the cord, and in bringing the stretch under control, a certain elasticity is retained to prevent a brittle condition which would affect tensile strength. Remember: GILMER NORMALIZED CORDS.
GILMER ENGINEERING SERVICE
Whatever your design problem may be, remember that Gilmer's Design Engineers are at your service, ready to give you the benefit of their skill and knowledge. See Sweet's new File for Product Designers for handy condensed specifications or write for Gilmer's Belt Catalogues. Don't hesitate to ask for help on design problems.
Gilmer BELTS
L. H. GILMER COMPANY
Tacony, Philadelphia 35, Penna.
OLDEST FIRM OF RUBBER FABRIC BELT SPECIALISTS

Designing Automatic Machine for Ordnance Parts

(*Concluded from Page* 118)

While held above the collet the tube is turned angularly and dropped into an inclined chute where it slides lengthwise onto the discharge conveyer, as indicated in *Fig.* 4.

Operation of the machine is timed by properly co-ordinating the oscillations of the operating-station head with the rotation of the work table. The head is set with all stations in alignment with a work-holding collet and securely fixed in this position. While it is possible for misalignment to occur, through wear or improper adjustment, the adjustable feature permits a realignment without undue difficulty.

Inspection Dial Aids Adjustment

In order to maintain a close watch on the performance of the machine an inspection dial is located in full view on the top of the base on the left-hand side, *Fig.* 1. This is a rotating plate driven by the machine at a speed of one revolution to an operating cycle. The plate is graduated in degrees. A zero or some form of registering means is located on the machine. In setting the head the zero of the dial is aligned with the zero on the base. The head turns through a predetermined number of degrees which for reading purposes is marked on the dial. To be correctly adjusted this reading must register with the zero on the base. Any misadjustment can be quickly detected in degrees or fractions thereof.

Detail construction has been given careful attention. Welding has been extensively used in fabricating small details as well as the larger assemblies already mentioned. Gray iron castings were also used for various members. All cams are steel castings to maintain wearing surfaces. Self-aligning bearings are used throughout the machine.

For lubrication, the zerk system is used throughout, the fittings being placed for convenient use. Some are placed directly on the parts to be lubricated while others are provided with piping leading to inaccessible surfaces.

Compactness of assembled parts is an outstanding feature. However, the ease of assembling was not neglected. Suitable openings are provided to insure accessibility for either assembling or maintenance.

Appearance of the finished machine was not ignored. The frame, doors and guards were first coated with a light gray metal primer. This is an antirust coating which also adds smoothness to the metallic surfaces. A final coat of medium gray gloss enamel was applied.

MORE IS BEING LEARNED about the transformation of steels at subzero temperatures and the process shortly is expected to have many applications other than in simply making expansion fits. Hardness of ordinary nickel carburizing steels such as SAE 2315 runs from 52 to 58 rockwell C with ordinary heat-treating methods but by refrigerating to minus 120 degrees Fahr. hardness ratings will "bounce" 12 to 15 points.

Choosing the Material

(*Continued from Page 126*)

ganese, .47 silicon, .30 nickel, .28 chromium and .13-.16 molybdenum, handled as a split heat, i.e., the part was poured without adding the intensifier, the rest with the boron-containing addition. The heat was fine grained, size 7 to 8 in the part without the addition, 7 in the part with it.

The maximum hardness attainable upon quenching a steel depends on its carbon content. The maximum hardness is predictable from the carbon content, and is determinable from the maximum reading obtained at the quenched end of the Jominy end-quench hardenability specimen.

If grain-coarsening and hardenability behaviors are specified and tested for, it is immaterial, from the point of view of tensile test results, by what alloying and addition elements or combinations thereof the final mechanical properties are produced.

NE Steels Need Revamping

One may heartily echo the conclusions of Orton and Carter[8], who say, "It is regrettable that the NE steels were not drawn up around hardenability and grain size requirements rather than analysis. Such a practice would permit full flexibility to the mills, with the maximum of efficient employment of our alloying resources. It is difficult to understand how, in the face of modern knowledge of the functions of the alloying elements, it can be maintained that it is necessary to know the exact chemicals on 90 per cent of the applications, even with today's severe war requirements. Such a practice would greatly facilitate warehouse stocking, a neglect of which has contributed today to shortages of many components. NE steels should be reviewed and reconstructed with the aid of the most advanced metallurgical knowledge."

Grossman[9] has clearly proved what was becoming fairly well understood; i.e., that the effect of alloying elements on hardenability is not merely additive, but is multiplicative. The cumulative effect of small amounts of several hardening elements is much greater than a corresponding larger amount of one only. The "residual" alloying elements in scrap thus need only a small amount to intensify their action enough to produce steels whose hardenabilities are on a par with those of the old, much more highly alloyed S.A.E. steels. Application of this principle, in the NE steels, has made it possible to produce the necessary tonnage of hardenable steel for munitions despite the ever increasing need for still more alloying metals.

The opportunity for increased application of the principle will be widened, the more the user forgets about the old chemical requirements for any steel, including the present NE steels, and specifies in terms of suitability for quench hardening in a given section, a specification that

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[8] Orton, R. E. and W. F. Carter—"Wartime Metallurgy Conserves Strategic Materials, Part XIII—Alloying Elements", MACHINE DESIGN, Aug., 1943, Pages 145-150, 224-228.

[9] Grossmann, M. A.—"Hardenability Calculated from Chemical Composition", *Metals Technology*, Vol. 9, June, 1942. Tech. Paper No. 1437. See also Field, J.—"Calculation of Jominy End-Quench Curves from Analysis", *Metal Progress*, March, 1943; Kramer, I. R., R. H. Hafner and S. L. Tolman—"Effect of 16 Elements on Hardenability of Steel", *Metals Technology*, Vol. 10, Sept. 1943, T. P. 1636.

brings the heat number rather than the NE number to the fore.

A study of replaceability of one alloy steel by others was carried out in England by a Technical Advisory Committee, as a war conservation problem, and was reported by Hatfield[10]. He points out that no one would use a Rolls Royce in wartime when a Ford would do. In producing a truck, airplane, destroyer, etc., everything turns on the understanding of the designer's brain concerning availability of materials and the properties of what is available, so that obtainable and suitable materials can be specified.

The Committee found that for parts requiring steel of 120,000 to 145,000 pounds per square inch tensile strength, there were in use—MnMo, CCr, CrMo, 3½ NiCrMo, 3 NiCr, 3 NiCrMo, and 3 CrMo; all those steels being used to provide the same mechanical result. "The designer might safely use any of these steels for the same purpose."

Moreover, for quite a wide range of dimensions, none of these steels, he says, is necessary at all, for, from an ordinary carbon-manganese steel, suitably hardened and tempered, the same results can be achieved. He suggests dividing steels into classes according to the diameter in which they harden fully. Thus, he groups them as, up to 1⅛ inches; 1⅛ to 2½ inches; 2½ to 4 inches; and 4 to 6 inches diameter. This grouping can be made on the basis of the standard hardenability test. For brevity then, we might speak of such groups as, e.g., one-inch oil, one-inch water, three-inch oil, three-inch water steels, without any reference to chemical composition.

Excess Hardenability Invites Cracking

Freedom from *excess* hardenability is beneficial to the user, since excess hardenability increases the propensity toward cracking and warping in quenching. What S.A.E. steels were previously employed for a particular use is nothing more than the roughest sort of indication as to what degree of hardenability is *needed*, because of the wide scatter of hardenability in different heats of S.A.E. steels prior to hardenability control, and because prior practice may have called for greater hardenability than the section requires.

Very often, an unalloyed carbon steel will prove exactly as good in the smaller sections, or where only the surface needs to be hardened, as the alloy steel that has crept into a particular use. Re-examination of such cases will often bring out unsuspected opportunities for saving alloys.

Another matter of interest to the user is the machinability of the steel. The structure of a substitute steel at the desired final hardness is necessarily the same as that of the steel formerly used, so no marked differences in machinability should occur. Boston[11] has reported that the NE steels are proving equally machinable with the ones they replace, so no trouble need be anticipated on that score.

So far we have been dealing with properties closely related to hardness. The heat treatments are varied to ob-

[10] Hatfield, W. H.—"The Rationalization of Special and Alloy Steels To Meet Wartime Needs", *Iron and Steel*, Vol. 26, Dec., 1942, Pages 66-77.

[11] Boston, O. W.—"Machinability of N.E. Alloy Steel", *Metal Progress*, April, 1943, Pages 543-547.

tain equal hardness with various combinations of alloying elements. The great mass of uses of these steels depends on their hardness and related properties, rather than on any one or several of the many other properties sometimes required. It is not contended that these various steels, merely because they have the same hardenability, are *exactly* alike in all respects. A steel using molybdenum to gain hardenability may require a higher tempering temperature to reach a given hardness than if certain other alloy additions had been used. Also, if .002 per cent boron imparts the same hardenability as .20 per cent molybdenum, the specific gravities of the two steels will not be *exactly* the same, though the difference is about 1 in 1500. In special cases users may require control of one or more properties in addition to the hardness properties. In such cases, mere equivalence in hardenability may not be enough. The metallurgist is accustomed to wrestle with such problems, and the answers to some of them are available.

Core Is Support for Surface

Steels heat treated in sections too large to harden completely to the center, although practically identical in the hardened zones, may be different in the unhardened center. This may or may not be material. The purpose of the core may be primarily to support the strong surface, and if the core is able to do this the core ductility and toughness may be of little moment.

In earlier days much importance was placed on toughness in the core of carburized or nitrided steels with hard, brittle cases. But when such a case is deformed enough to crack, the crack propagates rapidly through even tough cores, so the piece *as a whole* is brittle. Moreover, even if the piece would stand a little bending without snapping, the bending would ruin most hard-surfaced parts. A rather hard core is needed to support a very thin case and when the fetish of core toughness was accepted, the case upon a soft core has to be made thick enough to support itself, involving a waste in the long time required to produce the thick case.

Thin Cases Are Generally Used

Practice is tending toward the use of stronger cores and much thinner cases, as well as to flame or induction hardening of a surface skin, which hardening can be done in a jiffy, and for which plain carbon or low-alloy steels not only suffice, but are preferred.

The principle of giving the surface the properties wanted, without worrying much about the core, is applicable to most wear-resistant services. It is applicable to some, but not all, fatigue-resistant services. In rotary bending, as in the loading of a shaft, the maximum stress is at the surface and the stress decreases so rapidly as the distance from the surface increases that, if you "save the surface, you save all". But in axial loading, as in a connecting rod, where the whole cross section ostensibly carries uniform loading, weakness of the core does materially weaken the rod.

It is generally true, that in spite of ostensible axial loading, the actual loading is not axial but is a maximum at some point on the surface, and that, even here, strengthening the surface is far more effective than strengthening

William Lescaze, architect, is credited with the first modern skyscraper (for the Philadelphia Savings Fund Society), and the first use of glass brick in a facade. Outstanding examples of his work include Columbia Broadcasting's Hollywood Studios, the Ansonia (Conn.) High School, and Longfellow Bldg., Washington, D. C.

FROM A PILOT SEAT... AND RUBBER-LIKE SAFLEX... SOLID COMFORT, MASS PRODUCED?

STRONG, lightweight pilot seats of plastics-bonded plywood now in quantity production for the U. S. Air Forces were the principal inspiration for this interesting suggestion for 194X by well-known, New York Architect William Lescaze.

Wartime success, however, in converting Monsanto's Saflex from its original function as a tough, resilient interlayer for safety glass into what amounts to a new and promising synthetic rubber, also interested Mr. Lescaze and led him to include Saflex in his "specifications".

Making use of war-stimulated bag-molding techniques, the chair Mr. Lescaze visualizes would be quickly and easily formed on inexpensive molds with little or no waste of material. It would be upholstered with a resilient, sponge-like Saflex and covered with a waterproof, washable, Saflex-coated fabric.

The sketches below illustrate details.

Wood plys, coated with a Resinox phenolic bonding resin, would be laid up on simple, inexpensive wood molds, tacked in place.

Molds would be covered with rubber bag and air evacuated to form snug fit. Entire assembly then goes into pressure chamber.

Removed from mold, chair is one tough, resilient, monolithic piece. Sponge-Saflex cushion would be slipped on frame like an envelope.

The Broad and Versatile Family of Monsanto Plastics

(Trade names designate Monsanto's exclusive formulations of these basic plastic materials)

LUSTRON (polystyrene) • SAFLEX (vinyl acetal) • NITRON (cellulose nitrate) • FIBESTOS (cellulose acetate) • OPALON (cast phenolic resin) RESINOX (phenolic compounds)

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MONSANTO PLASTICS

SERVING INDUSTRY... WHICH SERVES MANKIND

FACTS TO HELP *YOU* SHAPE THE FUTURE

No one can say today with certainty that a chair such as Mr. Lescaze has suggested will ever be produced. It *is* certain, however, that wartime advances in plastics materials and techniques *will* exert a strong influence over the shape of many things to come. That is why it will pay you to add "The Family of Monsanto Plastics, A Guide for Product Designers," to your postwar file now. Its 24 pages are packed with facts on one of the largest and most versatile groups of plastics produced by any one manufacturer. Simply write: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield, Massachusetts.

of the core itself.

On this basis, a heat-treated, shallow-hardening carbon or low-alloy steel that gives only a thin, fully hardened shell and a "normalized" core on quenching, when tempered back to the proper structure of the shell may be as good for engineering service as a steel that hardens throughout and tempers to the same structure in both shell and core. But if the behavior of the part depends on getting strength in the core, as in the connecting rod example, then the core structure counts.

Full Hardening Is Not Often Needed

Full hardening on quenching strictly requires that the maximum attainable hardness be obtained *throughout the section*, at the center as well as at the surface. Actually, this has not often been demanded. If a steel that will quench-harden to 60 or 65 C rockwell on the surface, hardens to 50 C rockwell at the center, it is ordinarily considered sufficiently well hardened, even though the center is not 100 per cent the file-hard material that results from a full quench.

The way a steel responds to cooling rates between those of normalizing and of quenching is closely related to its behavior when "quenched" into a molten salt or analogous baths held at different temperatures within the 900-400 degrees Fahr. range, lies between the temperatures at which the change occurs to the normalized or to the quenched structure. Data so obtained are plotted in "S curves", so called from their shape. The interpretation of S curves takes metallurgical experience. The designer may, however, be interested in the comments of Orton and Carter[12] on S curves.

Specific Tests Needed

All discussions of the selection of NE steels as substitutes for S.A.E. steels emphasize that the user must, by some means or other, supplement the hardenability data by specific tests of his own to insure adequacy for his use. Equivalence of hardenability merely nominates candidates for scrutiny. It is for this reason that no handbook listing of "N.E. substitutes for S.A.E. steels" can be made with any degree of finality. Moreover, all the discussions of the NE steels further point out that shifts in the list of NE steels have already had to be made and further shifts are expected in the future, as availability of the alloying elements varies. It thus becomes necessary that the engineer be ready to evaluate not only the present substitute steels but also to anticipate the *future* substitute steels as well.

The evidence is complete that, insofar as properties are measured by the standard tensile test, one *completely* hardenable constructional steel, of a given carbon level, gives tensile properties practically identical with those of another completely hardenable steel of comparable carbon level, irrespective of the chemical composition of the material.

Information is being accumulated[13] on fatigue, notched-fatigue, and notched-impact, on the NE steels being used

[12] Orton, R. E. and W. F. Carter—"Wartime Metallurgy Conserves Strategic Materials", MACHINE DESIGN, Dec., 1942, Pages 91-95.
[13] Young, M. and H. H. Hanink—"N. E. Steels in Aircraft Engines", Report—Aircraft Materials and Processes Coordinating Subdivision, Society of Automotive Engineers. *Steel*, April 26, 1943, Pages 84-85, 126, 131 and *S.A.E. Journal*, May, 1943, Pages 157-164.

TANK DESTROYER PHOTO BY U. S. ARMY SIGNAL CORPS.

OSTUCO Contributes To Its Fire, Motive and Tractive Power

Developments in fire, tractive and motive power which are found in the tank destroyer have already proved their worth in front line action. What will these developments offer a world at peace? Manufacturers will reveal the answer as their blueprint plans take more definite shape.

Where is OSTUCO's place in this picture? Today OSTUCO seamless steel tubing meets strict demands of artillery, engines and caterpillar tread manufacturers, thus contributing to the tank destroyer's fire, motive and tractive power. When manufacturers' wartime design-engineering ingenuity and production experience are again concentrated on "plowshares," OSTUCO will be prepared to meet hardness, straightness, finish, tolerance and other specification requirements.

If you are working toward a favorable sales position for your products in peacetime you'll find OSTUCO's specialized experience a valuable production asset.

VICTORY REMINDERS: Buy more War Bonds . . . Write to the Men in Service. Get in the scrap . . . Be on the job every day.

THE OHIO SEAMLESS TUBE COMPANY

MANUFACTURERS OF SEAMLESS AND ELECTRIC-WELD STEEL TUBING

SHELBY OSTUCO OHIO

as replacements for S.A.E. steels in aircraft, and such evidence again indicates that in fully hardened steels drawn back to the same tensile strength these properties are thoroughly normal. But these evaluations by purely laboratory tests, though indicative, are not so completely convincing as are evaluations through service.

Many case histories of attempted, usually successful replacements of S.A.E. by NE steels are accumulating. Particularly interesting is the work of Widrig[14], who studied chipping of clash gears on full-sized gears in a special simulated service clash test and, with this test equipment available, put it to use in evaluation of some heats of NE steels of approximately equal hardenability with the previously used SAE 4320, since it was felt that the fatigue resistance and "toughness" required in clash gear service might be different, though it was concluded that "as to shafts and parts of that nature where gear teeth are not involved, hardenability tests are sufficient for proper selection of steels". He found, by the simulated service test, as well as by service, that "ordinary Charpy and Izod tests gave no indication whatever of actual resistance to impact caused by shifting gears in field tests". After adjustment to compensate for the different distortions of the NE 8600 and 8700 series, these NE steels are found closely comparable to SAE 4320 for clash gears.

Engineering Modifications Solve Problem

Wood and Sanders[15] developed an apparatus for studying the resistance of steering knuckles to repeated overstress, using actual full-size knuckles rather than endurance specimens, and applying measured stresses of the magnitude and direction met in service. They first determined the range of lives at the selected stress given by several lots of knuckles made from the steel X3140 that had previously been used in production, and then by those made from several other steels. In this comparison SAE 4140 gave knuckles that tested slightly better than X3140, but the supply situation was shifting so that 4140 would not be available. A third steel was then tried and gave a wide scatter in results at first but after engineering modification of fillet radii the scatter was reduced to normal and the average life increased.

In turn this third steel became unavailable, so NE 8744 was tried. The average and high values were satisfactory, but some low results were obtained. Shot-blasting the area of stress concentration was then resorted to. The *low* fatigue-life figure for this one selected stress rose to 639,000 against a *maximum*, with the original X3140 knuckles, of 241,000!

The search for a metallurgical substitute developed the fact that feasible engineering modifications were so much more potent than steel composition that the final results, using a mildly alloyed steel plus some mechanical engineering attention, far surpassed the original highly alloyed steel without that attention. These cases of simulated service testing produced acceptable proof of suitability of substitute steels.

(Continued in next issue)

[14] Widrig, S. L.—"N.E. Steels as Successfully Employed in Gears for Heavy-Duty Automotive Transmissions", *Steel*, Jan. 11, 1943, Pages 60-62.

[15] Wood, J. G., and R. F. Sanders—"Substitute Materials", *Automotive Industries*, Feb., 1943, Pages 36-37.

It's a Sterling
ELECTRIC MOTOR ...with greater perform-ability
Sterling Electric Motors enable you to achieve the maximum perform-ability you have designed into your machine because Sterlings are engineered and precision-manufactured to meet specific requirements.
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for Greater Perform-ability
Sm

Applying Standard Gearmotors

(*Continued from Page* 152)

second peak load of 180 per cent of normal motor rating, then stops and remains at rest for the remaining quarter of the cycle. This cycle is within the capacity of the intermittent-rated motor but requires a Class II gear for 8-hour day service. If the service were 24 hours per day, a Class III gear would be required.

There is a general tendency on the part of equipment design engineers to be conservative in selecting motors for most applications. When this tendency in motor selection is applied to motors for use with gearmotors, and the gear is properly classified by A.G.M.A. Standard Practice on the basis of the normal motor rating, then the conservatism in selecting the motor is also reflected in the gear and will result in equipment that will give long trouble-free life.

Correlating Motor and Gear Design

It must be remembered that motor engineers also are usually conservative in their design practices. When a gearmotor involves special motors or motors with high peak torque characteristics, particularly when connected to high inertia loads, the gearing parts stress analysis should be correlated with the test data of the actual motor involved. Probably the best way to illustrate this point is to refer to an actual installation. The example as used for illustration consists of a gearmotor driving a large indicating dial and the duty cycle was as follows:

Duty	Cycle	Load
Accelerate	1.0 second	3.02 horsepower
Run	1.5 second	.6 horsepower
Decelerate	1.0 second	1.95 horsepower
At rest	8.5 second	Zero

It was generally agreed by the equipment builders' engineers and motor manufacturers' engineers that a five-horsepower motor was satisfactory for the application. It was also decided that the motor should have characteristics similar to an elevator motor and should be two-speed type. This would allow the indicating dial to be operated at a much slower speed, when nearing the stop position, than that used for accelerating or normal running. Actual stopping of the dial was accomplished by a motor-mounted brake. The motor selected was 5/1.67 horsepower, two speed, two winding, 4/12 pole. Gear parts were designed for the loads and duty cycle specified. The gearmotor was only in service a few days when the gear parts failed. Upon investigation, it was discovered that the motor supplied was a standard 5/1.67 horsepower elevator motor with its inherently high peak torque values, rather than the torques just necessary for the load and duty cycle involved.

On a test of a duplicate motor, it was found the transient torque produced, when changing from the four-pole to the twelve-pole winding, was three times the pull-out torque. A new motor was then designed and installed having torque values in line with the application requirements. Duplicate gear parts were used with the

result that the gearmotor has operated satisfactorily ever since.

A point to remember in selecting gearmotors is that adequate foundations must be provided to withstand the output torque of the frame size involved. Too often engineers think in terms of horsepower rating and forget to consider the increase in torque due to the gear ratio when designing the foundations for gearmotors. Insufficiently rigid foundations cause a misalignment between the gearmotor and the driven equipment. This induces vibratory load of a magnitude depending on the varying degrees of misalignment and a flexing of the gearcase, and results in incorrect tooth action causing rapid gear tooth wear. *Fig.* 5 is a good illustration of the comparative size of a gear motor and a motor almost equivalent in horsepower and output speed.

Gearmotors Have Wide Applications

The field of application of gearmotors is apparently limitless, for in practically all types of machine design and mechanical transmission of power, there is required some form of speed reduction. As long as electric motors rotate at much higher speeds than the majority of driven equipment, there will continue to be a need for gearmotors. The gearmotor provides a compact unit, and combines high efficiency with low cost, neat appearance, few wearing parts, and long life.

Specification of a standard gearmotor will often simplify the driven equipment design. A special type gearmotor, or a standard gearmotor with some modifications, can often be made an integral part of, or flange mounted to, the driven machine. Due to any given gearmotor unit or frame size being obtainable with a number of different gear sets or ratios, the driven equipment can be operated at various speeds.

Variety of Mountings Available

Numerous types of standard mountings are available which the designer may specify, such as floor, side wall, ceiling, foot or flange mounting, and many special types of mountings can be provided for. Supporting feet on the great majority of gearmotors are so located that the unit can be mounted adjacent to the driven equipment and connected by means of a coupling or clutch, or if necessary, by means of an overhung pinion, pulley or chain sprocket.

For best performance and economical cost, small or medium-size motors should run at comparatively high speeds such as 1750 or 1150 revolutions per minute. Lower-speed motors are, of course, available but in most cases where machine drive shaft speeds are 700 revolutions per minute or below, it will be found more economical to use gearmotors. The advantages of gearmotors in efficiency, power factor, starting torque and cost increase rapidly as the machine speed decreases.

Gearmotors are available from most motor manufacturers and many gear manufacturers today. Standard listings show ratings from fractional up to 75 horsepower and standardized speeds from approximately four to 1430 revolutions per minute. Gearmotors are available with any standard type of motor and usually can be obtained with special motors in either alternating or direct current.

DESIGN ABSTRACTS

Designing Cars for Economy

IN VIEW of the probability that postwar taxation will be high, it seems to me that the car of the future will be smaller and considerably lighter than prewar models after the industry has swung from the prewar economic considerations which did not put much premium upon low operating costs.

In general these cars will be as roomy as their prewar prototypes. By functional designing, any of the "big three" could be reduced in weight to from 1900 to 2200 pounds and still have as much roominess. There has been a national mental attitude which demands a big package—it is the yen to keep up with the Joneses. The postwar cost of fuel, lubricants, and tires may make some difference in this point of view. But history shows clearly that a new model of a car is sold as are women's hats—partly as an innovation and partly as a utility. The innovation features permit the owner to brag, and the price they pay for that privilege is sometimes high.

The way to design an automobile is:

Determine the size of the seating compartment, with depths and heights of cushions, head room, leg room, and other space factors carefully computed, estimate the frame and body weight, and design an engine to pull this weight. Windows and doors must be functional if the vehicle is to be a success.

Let the stylist finish the remaining 10 per cent.

Too much of the prewar car was designed by stylists, with the result a sharp trend away from functionalism. The engineering departments of car companies have been forced to leave too much to stylists with the result that radiator grills and bumpers, for example, loom like motifs stolen from circus wagons.—*From a paper by Roscoe C. Hoffman, Borg Warner Corp., presented at a recent meeting of the Metropolitan section of the S.A.E.*

Pressure-Molded Castings

DIE CASTINGS were in the past used largely where it was a matter of low cost, minimum machining, pleasing appearance and high speed of production. They were not recommended for structurally responsible parts.

There is, however, no basic limitation in the die-casting principle which would rule out the possibility of obtaining structures and properties good enough and uniform enough to let them enter the field of mechanically responsible applications served by the best grades of sand castings, permanent mold castings, forgings, etc. It is only a matter of using proper machinery, intelligent die design, careful control of casting technique, metallurgical super-


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A request on your company letterhead will bring complete information.
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PILOT Universal MOTORS—A.C.-D.C. Fractional H.P. ratings ranging from 1/500 to 1/4. Motor requirements custom-built to specifications.
(A) PILOT Geared-Head MOTORS—A.C. or D.C. Fractional H.P. ratings from 1/1000 to 1/4.
(B) PILOT Shaded-Pole, Induction Type MOTORS—Fractional H.P. ratings from 1/500 to 1/15.
(C) PILOT BLOWERS—Standard and custom-built types to deliver from 12 to 200 C.F.M.
Pilot
Fractional H.P.
MOTORS

vision and strict quality control by inspection.

Prime considerations are:

1. Avoid spraying the molten metal in finely divided form in the die, to prevent oxidation of the individual metal particles as they enter the die and to prevent inclusion of air
2. Provide for sufficiently high pressure *when the die is filled,* so as to force reserve metal from the gate into the interdendritic shrinkage of the metal
3. Keep the metal in the gate at a temperature above the liquidus of the composition, so that the liquid metal forced into the interdendritic shrinkages will not segregate
4. Dies should be so vented that air is given a chance to get out without being trapped
5. Provide sufficient locking pressure at dies to prevent opening of dies under the tremendous pressure.

Intelligent die design implies effective gating, etc., to insure proper sequence of solidification, complete feeding of all parts of the casting and effective venting.

Casting control involves determination and maintenance of best die and metal temperature, speed of operation, die maintenance, lubrication of moving members, keeping the metal clean.

Metallurgical control should cover die steels and their heat treatment, check of all incoming material, control of composition in casting, correct utilization of gates and sprues, purification of melt, corrosion testing, mechanical testing, X-ray testing, spectrographic control and photomicrographs.

Quality control involves:

1. Control on the floor—check on maintenance of best casting practice by operator
2. Check *before shipment* to make sure that all acceptance requirements are met as to composition in casting, surface before and after machining, X-rays, end use, breakdown tests, tolerances and general dimensions
3. Making sure that all customers' complaints, etc., are transmitted to casting and metallurgical departments and taken care of.

In the past, Air Corps specifications did not permit any kind of die castings for a structurally responsible part. Now new specifications which have been drawn up by the Air Corps and A.S.T.M. with the assistance of the W.P.B. allow the use of so-called "pressure-molded castings" (they coined a special and distinctive new name in order to prevent competitive entanglements with commercial die castings) for parts in which the design load is more than about 40 per cent of the tensile up to about the elastic limit of the material.

It is my opinion, shared by many die casters, that pressure-molded castings after the war will open up to the die casters many fields hitherto closed to them and thus make up for that part of their business which they will inevitably lose to plastic, powdered metals, plaster-mold castings and various other newcomers in the field of low cost production. There will undoubtedly still be heavy production in the so-called commercial die castings where cost and general appearance are the principal considerations. However, as die casters handle more and more of the pressure-molded casting line the level of die castings quality is bound to rise in general.—*From a talk by W. Basch, General Electric Co., presented at the A.F.A. panel meeting at the recent A.S.M. convention in Chicago*

Business and Sales Briefs

IN BECOMING the new sales manager of the Leland Electric Co., Paul D. Dale takes the place of W. F. Lisman who recently has been appointed vice president and general manager. Mr. Dale had formerly been district manager of the company's Chicago territorial office. F. E. Schumacher succeeds Mr. Dale in this position.

♦

Effective January, 1944, Frank H. Carman will assume the position of general manager of Plastics Materials Manufacturers' association, Washington, D .C. Mr. Carman has been with the War Production Board since 1941.

♦

Formerly with Linde Air Products Co., John B. Ross has been appointed to the West Coast engineering office of Handy & Harman, serving California, Washington and Oregon territories.

♦

An announcement has been made by Rohm & Haas Co., manufacturers of Plexiglas acrylic resin sheets and rods, that their molding materials formerly known as Crystalite will henceforth be called Plexiglas molding powders.

♦

Recently another unit in the growing synthetic rubber industry—a 60,000-ton polymerization plant near Houston—has been placed in operation. Financed by the Defense Plant Corp. as part of the nation's war program, the plant will be operated by Goodyear Tire & Rubber Co., Akron, O.

♦

Figures indicate that self-locking nuts used in all United States planes are being produced at an extremely high rate, according to William T. Hedlund, president of Elastic Stop Nut Corp. of America. The company's production in one month almost doubled that produced six months ago, and tripled the rate for the same month a year ago.

♦

As sales representative in the Pittsburgh district for Jenkins Bros., manufacturers of valves, J. Murray Whitworth succeeds John J. Simpson who resigned to become general sales manager of the Pittsburgh Gage & Supply Co. Mr. Whitworth has been connected with the company's Philadelphia branch for the past seven years as a representative in Baltimore and Harrisburg.

♦

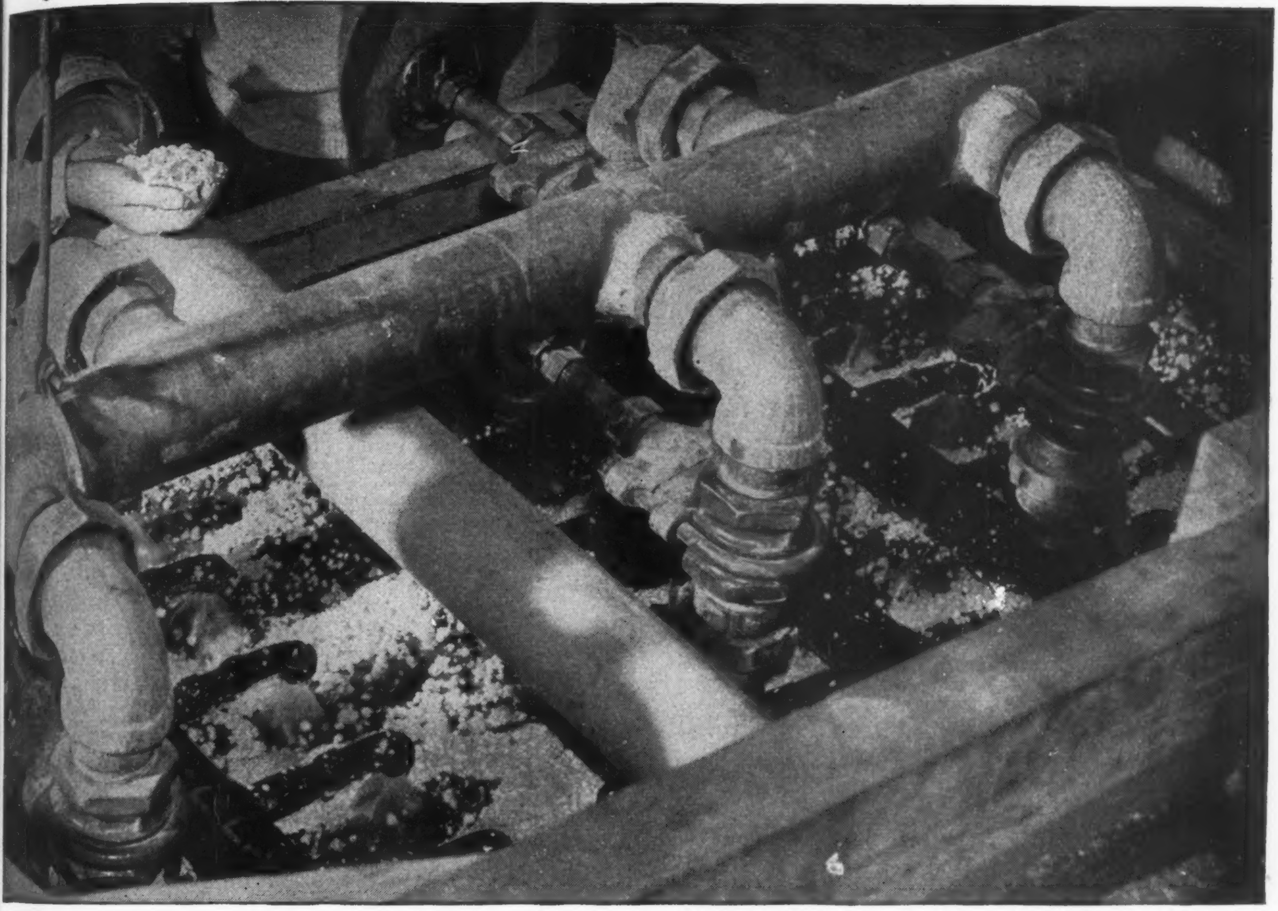
With the company since 1940, Morgan D. Lalor has been made assistant general sales manager for Reynolds Metals Co., Richmond, Va.

♦

Edward O. Jones has joined the engineering staff of Cook Electric Co. at the new Eastern division office at Greenwich, Conn. For the past seventeen years he has been with the General Electric Co. in charge of engineering applications of industrial equipment.

♦

Allegheny Ludlum Steel Corp., Brackenridge, Pa. has acquired the Carbide Alloy Corp. of New York city, to be oper-



OUT OF THESE FLOCS MAY COME THE FUTURE OF THE WORLD

These white crumbs or "flocs" look very unimportant in themselves . . . but on them may depend the future of the world. They are one of the first stages in the production of synthetic rubber, the most vital material being produced in America today.

Naturally, you are interested in synthetic rubber. But synthetic rubber is only incidental. What is really important is what happens to synthetic rubber after it is actually produced. It is chemistry that makes rubber fit to use, suits it to the task at hand.

United States Rubber Company is the largest manufacturer of rubber chemicals in the world. We have worked with rubber, improved it and broadened its uses for 100 years. Today, all this tremendous fund of knowledge of the chemistry of rubber is being drawn upon to improve synthetic rubber, perfect it for the jobs it must do for the Armed Forces and war industry.

The chemistry of rubber is what determines the final compounding and processing of the flocs of synthetic rubber you see here. They may eventually go into bullet-sealing hose, air ducts, or any one of a score of other parts used in the plane that will blast the last Nip carrier off the sea. They may be made into a tire that will rumble down bomb-battered Unter den Linden. They may go into some essential equipment like a conveyor belt that will keep America's war production line moving at top speed. They might very easily determine the entire course of the war, and thereby the future of the world.

Synthetic rubber, its production, compounding and application to war and industrial uses, is too big a story to present adequately here. There are five basic commercial types of synthetic rubber. Each of them has distinct properties and characteristics. Not a single one is ideal for all purposes.

Deciding which synthetic rubber to select and use for a particular task is an equally big story, a decision that requires expert knowledge and broad range experience.

We have told the story of the five basic commercial types of synthetic rubber, our more than twenty years of experience in working with them, and our twelve years of using synthetic rubber commercially in an interesting, informative booklet for business executives. Please ask for your copy on your regular business letterhead.

UNITED STATES RUBBER COMPANY

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In Canada: Dominion Rubber Co., Ltd.

ated as Allegheny Ludlum's Carbide division. The new division will produce a line of highly developed cemented carbides, produced under processes established by the Carbide corporation, and later activities will include developments which have long been under study in Allegheny Ludlum's research laboratories.

♦

Former vice president in charge of procurements for Crocker-Wheeler Electric Mfg. Co., Wallace K. Brown has been made manager of New York district sales for the company. He has been connected with the firm since 1908.

♦

Luther H. Atkinson has been made vice president in charge of sales for the Elastic Stop Nut Corp. of America. Formerly he had been connected with Weyerhaeuser Sales Co.

♦

Mass manufacture of industrial belting of synthetic rubber has been begun at the United States Rubber Co., plant in Passaic, N. J. This will alleviate the shortage of transmission and conveyor belting which first threatened war industries when sources of natural rubber were shut off.

♦

Joseph Stokes Rubber Co. in Trenton, N. J., and its subsidiary in Welland, Ont., has been acquired by the Thermoid Co. in order that the latter company may augment their industrial rubber sales division with the manufacturing capacity and "know how" on hard rubber and plastics which are being demanded by equipment manufacturers. No changes in the sales administration of the Stokes company are contemplated.

♦

Changes in the sales department personnel of the Wolverine Tube division of Calumet and Hecla Consolidated Copper Co., Detroit, include those of W. H. Maxwell as general sales manager and R. F. Moody as assistant general sales manager. Mr. Maxwell will divide his time between New York and Detroit, making Detroit his permanent headquarters after January 1, 1944.

♦

Previously known as Porcelain Enamel & Mfg. Co. of Baltimore, the company has changed its name to Pemco Corp.

♦

For many years vice president of Rheem Mfg. Co., Harvey A. Craig has been named district sales manager of Republic Steel Corp. in the Los Angeles district. Arthur C. Geldner will be assistant district sales manager in this territory.

♦

Appointment of Philip Hooker as sales and advertising manager of Arens Controls Inc., Chicago, has been announced. Mr. Hooker had been executive assistant manager of the contracts department at Bell Aircraft.

♦

New headquarters of the Shafer Bearing Corp. are at 1412 West Washington boulevard, Chicago. The new modern three-story building houses both executive and engineering offices as well as a modern laboratory and stockrooms.

♦

Heretofore vice president and general manager in charge of the Pershing Road plant operations and central division sales for Link Belt Co., Edward J. Burnell has been transferred to the executive office of the company, 307 North Michigan avenue, Chicago. In his new position he will be vice president in charge of sales for the entire company. Harold L. Hoefman, manager of the company's Atlanta plant succeeds Mr. Burnell as general manager of the company's Pershing Road plant in Chicago. Replacing Mr. Hoefman in Atlanta is Richard B. Holmes, former district manager at

Indianapolis. At the later office David E. Davidson, former district engineer from Detroit, will be district manager.

♦

Founder and president of Ohmite Mfg. Co., Chicago, David T. Siegel was recently elected to the board of trustees of Illinois Institute of Technology.

♦

Appointment of William C. Judy, 302 Sugar building, Denver, Colo., as district sales manager has been announced by Bliss & Laughlin Inc.

♦

Koppers Co. has purchased the assets of Coated Products Corp., Verona, Pa. It will be operated as the Coated Products division of Koppers, with Morton I. Dorfan as manager.

♦

Election of R. J. Russell, vice president and sales manager, Century Electric Co., St. Louis, as president of Associated Industries of Missouri has been announced.

♦

Announcement has been made of the appointment of Joseph B. Terbell as first vice president of the Manganese Steel division, Chicago Heights, Ill. Prior to this advancement he had been eastern sales manager of American Manganese Steel division, American Brake Shoe Co., New York.

♦

Purchase of the manufacturing plant and inventory of the Link Belt Supply Co., Minneapolis, by the Link-Belt Co. has recently been made. The Supply company had served as an authorized distributor of Link-Belt Co. in Minneapolis, St. Paul, and adjacent territory. The entire Minneapolis organization will be retained, facilities will be improved, and stocks expanded. Ray S. Wood, the new plant manager, started his career with the company in 1914 in the engineering department at Philadelphia.

♦

Two more service and sales district offices have been opened by Michigan Tool Co., Detroit. The new branches are located in 601 Tower building, South Bend, and 1409 Union Life Insurance building, Cincinnati. District managers are T. S. Mellen in South Bend, and E. W. Brock in the Cincinnati area.

♦

Former central division sales manager, Detroit, of United States Rubber Co., Michael N. Brady has joined National Enameling & Stamping Co., Milwaukee, as vice president in charge of sales.

♦

C. V. Topliffe has been appointed manager, Boston district office Cutler-Hammer Inc., Milwaukee.

♦

Effective immediately is the appointment of F. W. Warner as assistant engineer of the plastics division of General Electric Co., Pittsfield, Mass. Mr. Warner will continue his present work as project engineer and also will be responsible to the engineer of the plastics division on engineering development and general administrative work.

♦

Opening of a new office in the Commercial Trust building, Fifteenth and Market streets, Philadelphia, has been announced by the Blackmer Pump Co., Grand Rapids 9, Mich. The new office will be in charge of B. Dunkley who has specialized in industrial pumping problems and is well known for his

work in that field. Included in the area served are Eastern Pennsylvania, Southern New Jersey and a part of Delaware.

♦

In his new post as vice president of Lukens Steel Co., J. Frederick Wiese will be in charge of the combined sales of the Lukens company and its two subsidiaries. Since 1939 Mr. Wiese had been general manager of sales of Lukens, and in 1940 became manager of combined sales of the company and its subsidiaries.

♦

Assisting W. R. Persons, Pittsburgh district manager of Lincoln Electric Co., Cleveland, H. E. Cable has been appointed representative.

♦

Recent appointment has been announced of F. B. DeLong as vice president and general manager of sales, Columbia Steel Co., West Coast subsidiary of United States Steel Corp., Pittsburgh. Mr. DeLong was formerly vice president in charge of sales in the Los Angeles district. He succeeds J. R. Gregory, who has been made vice president of sales, Geneva Steel Co., a newly formed United States Steel subsidiary at Geneva, Utah.

♦

Formerly assistant executive vice president, Ohio Ferro Alloys Corp., Canton, O., J. C. Vignos has been named general sales manager to succeed H. A. Landon who has become Pacific Coast representative for the company.

♦

An addition to its plant is being planned by Air Maze Corp., Cleveland, according to a recent announcement. It is expected to be a one-story addition to its present plant at 5200 Harvard avenue, Newburg Heights, Cleveland.

♦

It is planned by American Brake Shoe Co., 230 Park avenue, New York, to double the plant of Electro Alloys Co., Elyria, O., which it has acquired and will operate as a subsidiary. W. C. Whyte is vice president of Electro Alloys Co.

MEETINGS AND EXPOSITIONS

Dec. 6-11—

Exposition of Chemical Industries. Nineteenth exposition to be held at Madison Square Gardens, New York. Exposition under management of International Exposition Co., Grand Central Palace, New York. Charles F. Roth is president.

Jan. 10-14, 1944—

Society of Automotive Engineers. Annual meeting and engineering display to be held at Book-Cadillac hotel, Detroit. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary.

Jan. 24-28, 1944—

American Institute of Electrical Engineers. Winter technical meeting to be held in New York. Additional information may be obtained from headquarters at 33 West Thirty-ninth street, New York. H. H. Henline is national secretary.

Jan. 31, Feb. 1-2, 1944—

American Society of Heating and Ventilating Engineers. Fiftieth anniversary meeting to be held at Hotel Pennsylvania, New York. A. V. Hutchinson, 51 Madison avenue, New York 10, is secretary.

Feb. 21-22, 1944—

Society of the Plastics Industry. Pacific Coast Section conference to be held at Ambassador hotel, Los Angeles. James D. McDonald, 544 East Thirty-first street, Los Angeles 11, is chairman of the Pacific Coast Section.

Make it with
TUBING
The pressure under which American industry is working to keep abreast of the demands for war materials has emphasized the need for time, labor and cost saving in mechanical operations. Babcock & Wilcox Seamless and Welded Steel Tubing has aided this economy by its ready adaptation to a wide variety of parts and structural uses.
B&W Seamless or Welded Tubing can be used as machining stock for hundreds of small parts formerly processed from solid stock. Time spent in re-tooling your equipment will quickly be made up in increased production at low cost.
B&W TUBING IS MADE IN A VARIETY OF TESTED STEELS. AMONG THEM ARE:
• Carbon Steels
• S.A.E. Alloys
• Carbon Molybdenum
• High-Strength Alloys
• B&W Croloys
• Stainless and Corrosion-Resisting Alloy Steel
SEAMLESS
B&W Seamless Tubing is made in a complete range of carbon and alloy steels and in sizes from ½ in. to 8⅝ in., O. D.
WELDED
B&W Resistance Welded Tubing is produced in carbon grades in sizes ranging from ¾ in. to 4 in., O. D.
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SEAMLESS TUBE DIVISION
BEAVER FALLS, PA.
WELDED TUBE DIVISION
ALLIANCE, OHIO
TA-1268

NEW MACHINES—

And the Companies Behind Them

(For illustrations of other outstanding machinery, see Pages 154, 155)

Agricultural

Corn husking machine, Morral Bros., Morral, O.

Armament

*Clip loading machine, Package Machinery Co., Springfield, Mass.
*Antitank mine coating machine, Barry-Wehmiller Machinery Co., St. Louis.
X-ray for checking hand grenade fuses, General Electric Co., Schenectady, N. Y.

Construction

Crushing and washing plant, Pioneer Engineering Inc., Minneapolis.
Tractor-type rodding machine, Whiteman Mfg. Co., Los Angeles.

Engines

*Eight-cylinder, 1000-horsepower supercharged gas-engine-driven compressor, Clark Bros. Co., Inc., Olean, N. Y.

Finishing

Portable, electrically-heated combination metal-cleaning and rinsing tank, Aerial Burner Co., West New York, N. J.

Instruments

*Internal-external measuring instrument, The Sheffield Corp., Dayton 1, O.

Materials Handling

Tailgate loader, Anthony Co., Streater, Ill.
Cyclograph for checking, sorting and analyzing metals by electronics, Allen B. Du Mont Laboratories Inc., Passaic, N. J.
Wire wind-up machine, Industrial Oven Engineering Co., Cleveland.
Screw and rivet sorter, Tubin Engineering & Mfg. Co., Los Angeles 14.

Metalworking

Plain milling machine, Abrasive Machine Tool Co., Providence, R. I.
Hollow spindle lathe, Lehmann Machine Co., St. Louis 3.
Tube cutting machine for straight and angle cutoff, De Walt Products Corp., Lancaster, Pa.
Turret punch press, Weidemann Machine Co., Philadelphia.
Straight wheel grinder, Samuel C. Rogers & Co., Buffalo.
12 x 14-inch planer, Boice Crane Co., Toledo, O.
*Gear shaving machine, National Broach & Machine Co., Detroit.
*Heavy-duty precision surface grinder, Hill Acme Co., Cleveland.
*Wet and dry abrasive belt grinder, Hammond Machinery Builders Inc., Kalamazoo 54F, Mich.
Integrally built hydraulic joggling press, Beatty Machine & Mfg. Co., Hammond, Ind.
High-speed, automatic nut tapping machine, Bodine Corp., Bridgeport, Conn.
35-ton hydraulic bender, Beatty Machine & Mfg. Co., Hammond, Ind.

Sanitation

High-speed chopping machine for disintegrating sewage screenings, Chain Belt Co., Milwaukee.

Testing

Starter test stand, Airplane Mfg. & Supply Corp., North Hollywood, Calif.
30,000-volt portable oil tester, General Electric Co.
Optical comparator, Portman Machine Tool Co., New Rochelle, N. Y.
Angle computer, The Angle Computer Co., Los Angeles.
Portable test set, General Electric Co., Schenectady, N. Y.
Hydraulic testing machine, Riehle Testing Machine Division, American Machine & Metals Inc., East Moline, Ill.

Textile

Padder mangle, Textile Machinery Division, Rodney Hunt Machine Co., Orange, Mass.
Fluid impact mill, Asbury Impact Mill Co., Abington, Pa.

Welding

Universal resistance welder, Eisler Engineering Co., Newark 8, N. J.
Portable seam welding machine, Progressive Welder Co., Detroit 12.
Portable spot welder for aluminum alloys, Sciaky Bros., Chicago.

Woodworking

*Pneumatic high-speed, opposed pad sander, Sundstrand Machine Tool Co., Rockford, Ill.

*Illustrated in pictorial spread, Pages 154, 155.

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Plane motors	Army trucks	Submarines
Instruments	Scout cars	Torpedoes
Parachutes	Jeeps	Machine guns
Trainers	Destroyers	Automatics
Tanks	Cruisers	Gun carriages

When that job is done, Wissco springs and formed wires will be ready to help win the Peace, by contributing their efficiency to better automobiles, refrigerators, vacuum cleaners and the multitude of other products of American industry.

Back of Wickwire Spencer super-dependability are 122 years of pioneering many of the basic advances in wire and wire products . . . and the accumulated skill of the thousands of Wickwire Spencer crafts*men* and crafts*women*. When *you* want wire or wire products, put your needs up to experts. Write for data book.

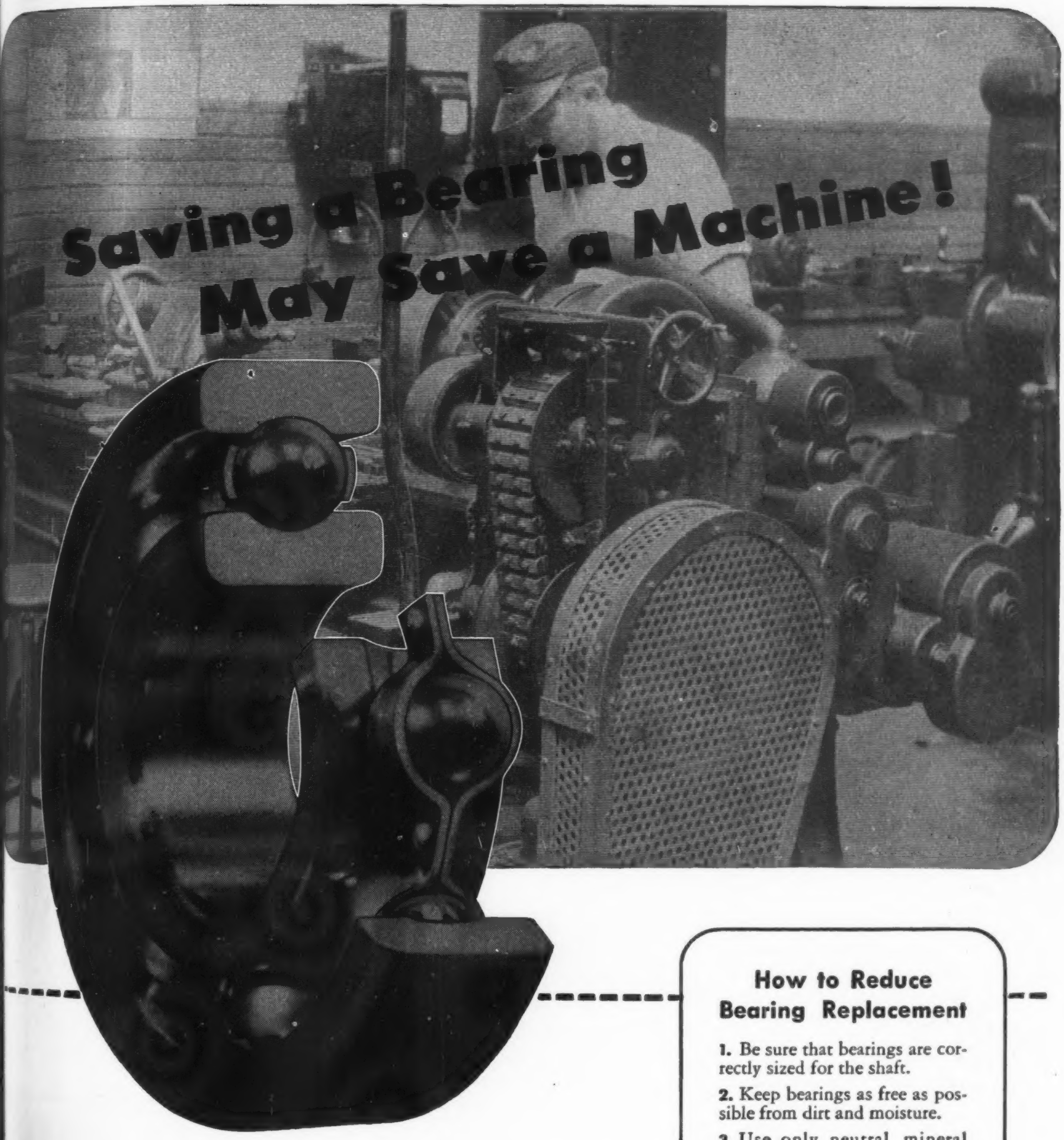
WICKWIRE SPENCER STEEL COMPANY

500 FIFTH AVENUE NEW YORK (18), N. Y.

Worcester, Philadelphia, Buffalo, Chicago, Chattanooga, Detroit, San Francisco, Los Angeles, Tulsa, Houston, Abilene

FAMOUS FOR QUALITY IN WIRE, WIRE ROPE, SPRINGS, METAL CONVEYOR BELTS, INDUSTRIAL WIRE CLOTH, POULTRY NETTING, HARDWARE CLOTH, INSECT SCREEN CLOTH, ELECTRICALLY WELDED FABRIC FOR CONCRETE

STANDS FOR FRIENDLINESS



NO matter how small the bearing, it plays a big part in machine operation. Proper machine maintenance *must* include proper bearing maintenance. The easily followed suggestions (at right) lengthen the life of hard-to-replace BCA Ball Bearings . . . help to avoid machine damage and shutdown.

BEARINGS COMPANY OF AMERICA, LANCASTER, PENNA.

BCA

RADIAL • ANGULAR CONTACT • THRUST

BALL BEARINGS

How to Reduce Bearing Replacement

1. Be sure that bearings are correctly sized for the shaft.

2. Keep bearings as free as possible from dirt and moisture.

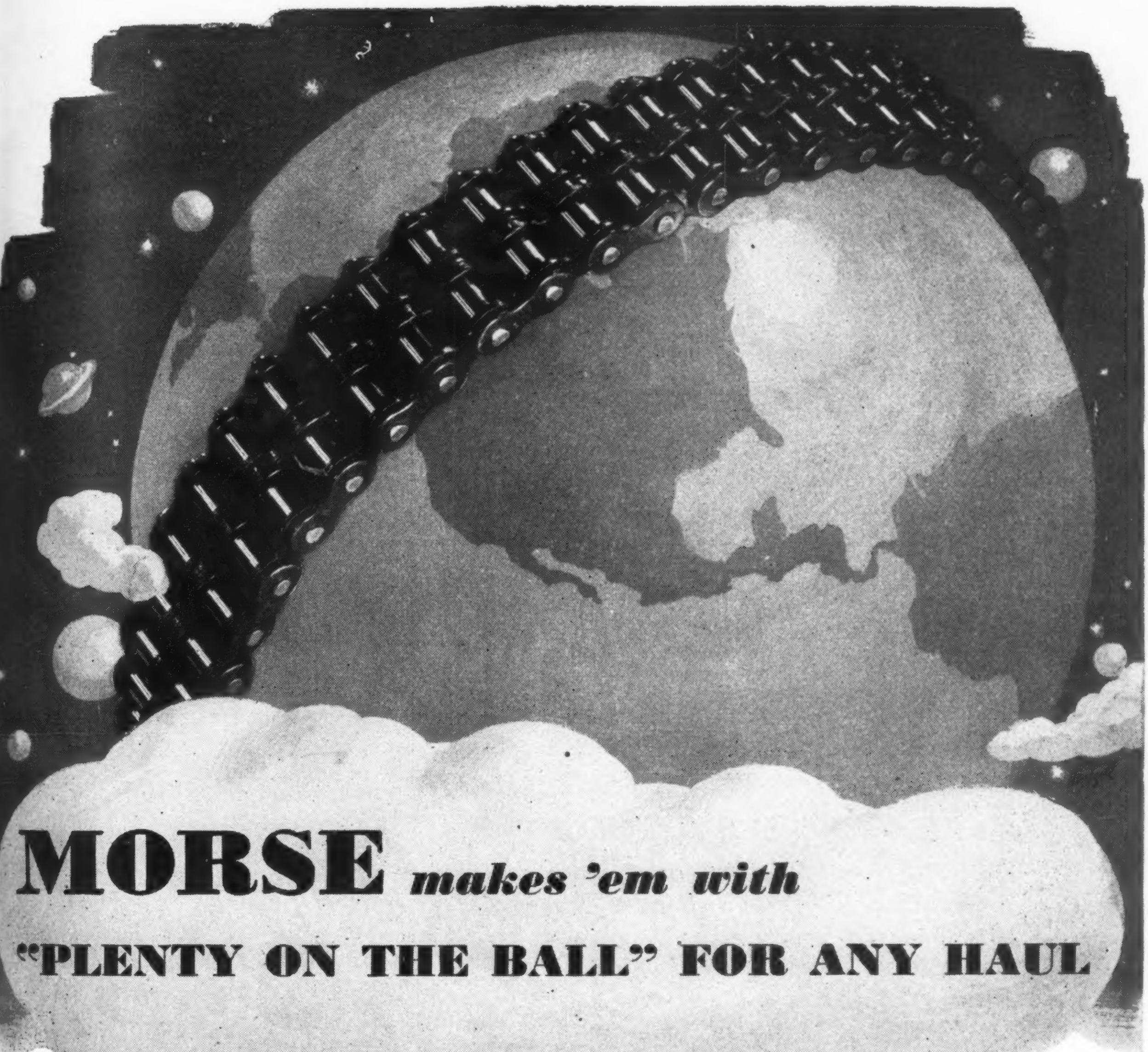
3. Use only neutral mineral lubricants.

4. When lubricating with oil, keep only enough in the housing that the lowest ball dips in to one-half its diameter. With grease, do not have the housing more than one-half to two-thirds full.

5. Keep bearings in their original wrappings until they are to be mounted.

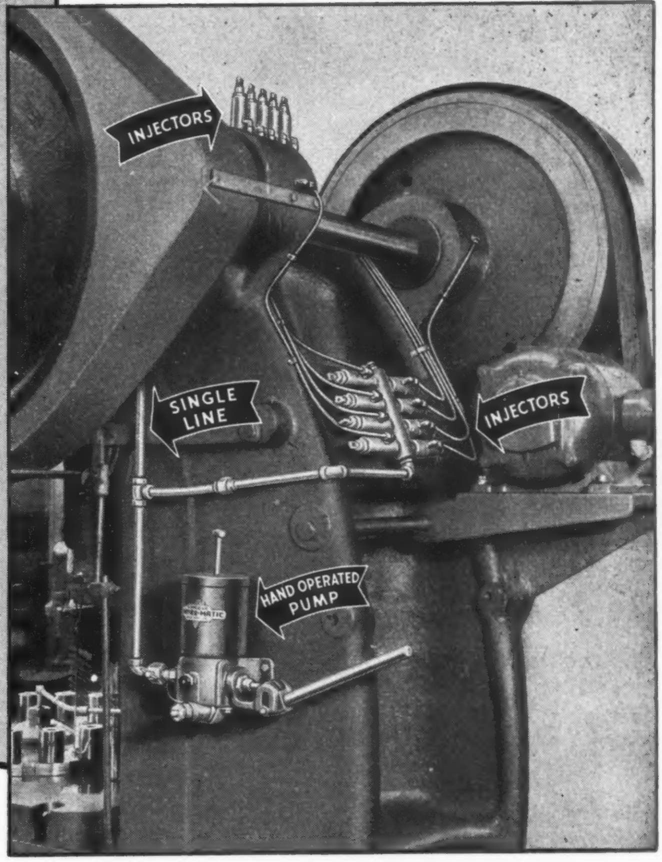
6. Before mounting, thoroughly clean the shaft and housing.

Treat Bearings Right! They're in the Fight!


MORSE makes 'em with
"PLENTY ON THE BALL" FOR ANY HAUL

LINCOLN CENTRO-MATIC LUBRICATING SYSTEMS

cut down on bearing failures --and prevent delays in war production



These modern centralized lubricating systems are easily installed on new or old machines

Lubricate *all* bearings from a central source . . . Reduce the threat of bearing failures . . . Save man-hours . . . It's possible with Centro-Matic Systems.

Under the Lincoln method you are sure that each bearing will get the proper amount of grease, and that no bearings will be overlooked. Service is performed quickly and economically—without stopping machines.

A Centro-Matic System consists of a number of Centro-Matic Injectors—one for each bearing—and a power operated or a hand operated Centro-Matic Lubricant Pump. A power operated system can be push button or time clock control...Only a single lubricant supply line is required...Easily installed on new or old machines. (Illustration above shows manually operated Lincoln Centro-Matic Lubricating System installed on a punch press).

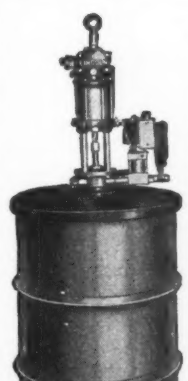
The ARMY-NAVY PRODUCTION AWARD for high achievement in the production of war equipment, conferred upon the Lincoln Engineering Company has had a star added. This star symbolizes 6 more months of exacting service to our Armed Forces, delivering vital materials so necessary for ultimate Victory.

Write us today for complete information 143-47

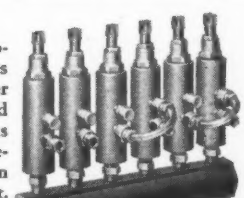
LINCOLN ENGINEERING COMPANY

Pioneer Builders of Engineered Lubricating Equipment

5701 NATURAL BRIDGE AVENUE, ST. LOUIS 20, MO., U. S. A.

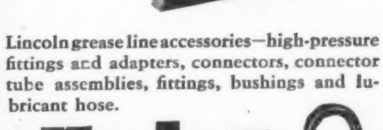


Lincoln Model 1774 Air motor operated, 400-lb. drum pump. Pumps lubricant direct from original refinery container and is full automatic with time clock control.



Lincoln Centro-Matic injectors can be used either in manifold groupings or as single units depending upon the requirement.

Lincoln grease line accessories—high-pressure fittings and adapters, connectors, connector tube assemblies, fittings, bushings and lubricant hose.



Lincoln Model 1805, Manually operated Centro-Matic Pump, 2-lb. capacity.

Model 81625 hand operated Filler Pump provides a quick, clean, easy and economical method of filling Centro-Matic Stationary Lubricant pumps.

PRODUCTION PROBLEMS ARE OUR DISH

Pass your hard-to-solve production problems along to Joyce—they're our dish. We don't wish to imply that we prefer the difficult assignments to the run-of-mill jobs—what we want to establish is that we've had such broad experience in production procedure and product improvement that we're confident we can help you materially in meeting your war contracts—and in your postwar planning. Whether it be the designing of special machines or the quantity production of products or parts, Joyce's extensive facilities are available to assist you.

Joyce's huge force of skilled craftsmen have proved themselves in maintaining a constant flow of war materials for the Army, Navy, Maritime and Aircraft services—and their ability to get things done has helped many of the country's leading industrial plants score enviable production records.

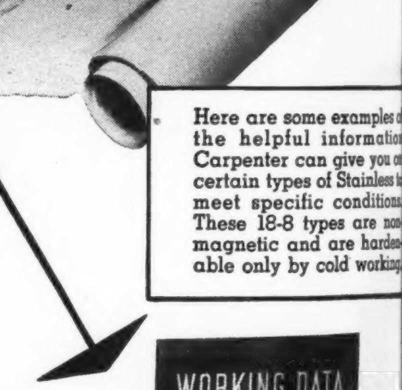
A Joyce representative will be glad to explain in detail the many phases of Joyce's design, assembly and fabricating service. If it can be made better, faster, more economically, Joyce "know how" will find the way.

★ *Hit Hitler Hard*
Buy Bonds for Bombs ★

JOYCE
Machine Company
2080 WHEATSHEAF LANE • PHILADELPHIA
★
MANUFACTURERS OF PRECISION PARTS FOR ALL KEY INDUSTRIES

BEHIND THE MAN ▶ BEHIND THE MAN ▶ BEHIND THE GUN

Here are some examples of the helpful information Carpenter can give you on certain types of Stainless to meet specific conditions. These 18-8 types are non-magnetic and are hardenable only by cold working.



In giving your old or new products the benefits and advantages of Stainless Steel, it is necessary to decide what physical properties, corrosion resistance, and fabricating qualities are needed to meet your specific job requirements.

The popular 18-8 Stainless Steels provide exceptional physical properties, maximum corrosion resistance and excellent fabricating characteristics. There are many applications where these Stainless types can be used to give products longer life and greater utility on the job. To get the most out of 18-8 Stainless, it will pay you to consult Carpenter, who pioneered the development of Stainless Steels, and who, for years, has been helping to solve the problems of Stainless users.

For complete information on all types of Stainless available from Carpenter, write us for a copy of the helpful 98-page book, "Working Data for Carpenter Stainless Steels". This book simplifies the selection, engineering and fabrication of Stainless Steels. It is free to Stainless users in the U. S. A. Just drop us a line on your company letterhead.

THE CARPENTER STEEL COMPANY • 120 W. BERN STREET • READING, PA.

"PERFECT"
Oil Seals
PATENTED

This issue at a glance

That Confusing Materials Picture . . . .

is greatly clarified by findings of the War Metallurgy Committee. Its report, prepared at the request of WPB, is clear and comprehensive, yet concise. It interprets the most timely materials information available. Part I of a series abstracted from this invaluable report commences on Page 121. Here is an excellent authoritative guide for competent selection and substitution of materials.

Hydraulic Lines Can Be Weak Links . . . .

in an otherwise efficient hydraulic system. They must not restrict flow unduly . . . . produce unwarranted pressure drops. Nor must they give way—burst. For pertinent factors influencing selection and utilization of these mechanical veins, turn to Page 145. Information is presented in readily understandable manner. You'll want to retain the charts for future reference.

Focus On Brazing Has Been Sharpened . . . .

by our war-whipped industries' demands for better processes . . . . more economical production of machine parts. Information on the characteristics of brazing alloys and properties of brazed joints—butt, scarf and lap—brings the design engineer's conception of a notable fabrication process up to date. See Page 136 for the first of a significant two-part series.

Plastic Parts Design Is Influenced . . . .

in many ways by characteristics of tools producing them. Best molded parts spring from the boards of designers who are armed with "die-visualization" ability. Highest production rates—with attendant economies—predicate practical knowledge of the merits and limitations peculiar to die-molding processes. Page 139.

Strip Steel Specifications Are Affected . . . .

by fabrication requirements. Varying grades called for by different production operations such as deep-drawing, forming, bending, seaming, etc. Hot and cold-rolled strips classified by temper, surface and edge. Article discusses purposes for which each type is most suitable, parts defects due to flaws in steel, scratched surfaces, etc. Page 130.

There's *Always* A Better Way . . . .

of doing almost anything. Designers, eager to keep abreast of the latest developments in their field, will want to read Scanning the Field for Ideas. It is one of the many departments appearing regularly in MACHINE DESIGN. Puts the emphasis on "learn from the other fellow"—offers significant current design accomplishments. Discusses briefly—illustrates fully. Page 119.

How are you at magic?

WHAT we have to say here is of concern to practical, hard-working development and production men who are constantly facing operating problems and don't expect any magic to solve them.

To you we want to emphasize that the way to solve many of these problems is by the use of Hycar synthetic rubber. And here's why:

Hycar can be tailor-made for the job. Oil-swell can be positively controlled (even held to zero)—insuring dimensional stability of parts. Hycar is 20% to 25% lighter than many other synthetics and it *stays* light because it does not continually absorb oil or moisture. Hycar has an operating range of —65° to 250° F. It resists abrasion 50% better than natural rubber. Its compression-set characteristics are outstanding.

These are the qualities that engineers and sales-minded business men have sought for years for oil and fuel hose, hydraulic lines, motor mounts, vibration dampeners, gaskets, seals, packing and scores of other resilient parts. They are the qualities that will result in better, more care-free performance and lower maintenance cost in your operations. All our years of experience in synthetic rubber are at your service. *Hycar Chemical Company, Akron 8, Ohio.*

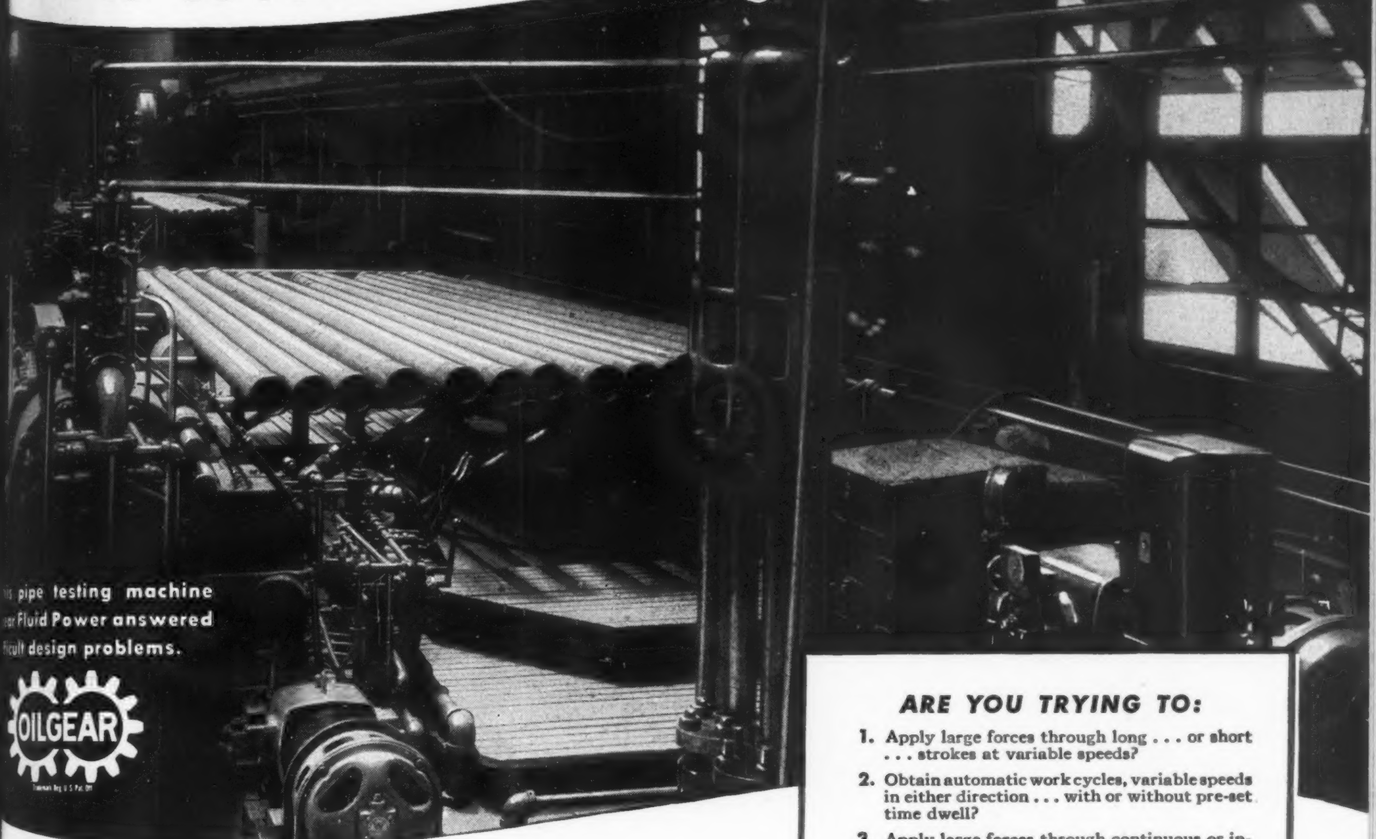
Hycar

LARGEST PRIVATE PRODUCER OF BUTADIENE TYPE

Synthetic Rubber

Because of Hycar's outstanding performance in war uses the demand far exceeds the supply. However, limited quantities are available for experimental work so that your supplier of rubber products may obtain small amounts to permit you to make tests in your own applications, both present and future. It's to your advantage to gain experience now against the day you will need new and even better resilient products. Our technical staff and laboratory are ready to help.

hrow a needle through a Haystack?



Oilgear Fluid Power has solved more difficult problems

IT may sound foolish to talk about throwing a needle through anything ... but Oilgear Fluid Power furnished ust the right answer to *that* problem in the design of wire-braiding machines. Oilgear provided a mechanism that ould rapidly reciprocate the necessary machine part without it tearing everything to pieces as previous constructions had always done.

Your machine design problem may be quite different. You may want steplessly variable speed control of some function . . . or a simple means of applying great pressure . . . or a way of synchronizing a group of motions . . . or perfect sequence or cycle operation . . . or any one of dozens of Oilgear answers to problems that appear virtually impossible—*until you know Oilgear Fluid Power.*

For a quarter century Oilgear engineers have worked with executives and designers of hundreds of companies building machines and mechanisms of widely diversified use. The combination of Oilgear experience and know-how with the remarkable possibilities inherent in Oilgear Fluid Power equipment may be the very answer to *your* long-sought perfected machine. *Now* is the time to find out. The Oilgear Company, 1305 W. Bruce Street, Milwaukee, Wisconsin.

ARE YOU TRYING TO:

1. Apply large forces through long . . . or short . . . strokes at variable speeds?
2. Obtain automatic work cycles, variable speeds in either direction . . . with or without pre-set time dwell?
3. Apply large forces through continuous or intermittent reciprocating cycles at constant or variable velocities?
4. Obtain extremely accurate control of either position or speed of a reciprocating member?
5. Apply accurately variable pressure either static or in motion?
6. Closely synchronize various motions, operations or functions?
7. Apply light . . . or heavy . . . forces at extremely high velocities through either long or short distances of travel?
8. Obtain continuous automatic reversing drives at constant R P M or over a wide range of speed variation?
9. Obtain accurate remote control of speed and direction of rotation, rates of acceleration and/or deceleration?
10. Obtain constant horsepower output through all or part of a speed range?
11. Obtain automatic torque control?
12. Obtain accurately matched speed of various rotating elements?
13. Obtain constant speed output from a variable speed input?
14. Obtain full pre-set automatic control, elimination of problems of shock, vibration, etc.?

You Need Oilgear!

OILGEAR
Fluid Power

Never Before - A Motor Like This

You've never seen a motor like this new Fairbanks-Morse Motor, because never before have so much stamina, versatility, and protection been built into one motor housing!

CHECK THESE POINTS . . .

✓ **1.** *40° C. Motor.* ✓ **2.** *Protected frame.*

✓ **3.** ***Conduit box* has controls that give new meaning to "adaptable," "convenient," and "handy."**

✓ **4.** **Famous Fairbanks-Morse COPPERSPUN Rotor—the *ONLY* rotor centrifugally cast in *ONE* piece and of *COPPER*.**

If you are buying motors now but want them to be up-to-date for postwar production, see this motor demonstrated. *There's no other way to appreciate how much more it offers you!* Fairbanks, Morse & Co., Fairbanks-Morse Building, Chicago 5, Illinois.

FAIRBANKS-MORSE

DIESEL ENGINES · WATER SYSTEMS · PUMPS · SCALES · MOTORS · STOKERS · GENERATORS · FARM EQUIPMENT · RAILROAD EQUIPMENT

Motors

Can your product use the Pressurized Power in this Plane?

★Have you ever watched a bomber fold its giant landing wheels into its wings?

The pressurized power that does this job is what we want to sell you. It is a hydraulic power system of entirely new efficiency and dependability . . . engineered for aircraft, available for all industry.

As a result of PESCO's more than ten years' specialization in making aviation pumps and related accessories, you will be able to equip your plant or product with a radically improved pumping system. For instance, you can have a compact, precision pump that delivers pressures up to 3000 pounds per square inch. This pump, weighing less than 4 pounds, forms the heart of a PESCO pressurized power system with endless uses in industry for transmitting or controlling power.

In addition to hydraulic pumps, PESCO builds pneumatic, vacuum and fuel pumps of equally high efficiencies, meeting practically all needs for pressurized power or controlled liquid flow.

The performance of PESCO equipment in your plant or product . . . its greater efficiency, dependability, and longer years of service . . . is assured by the fact that it has been engineered to operate under flying conditions which are far more extreme and demanding than any encountered down on earth. Won't you let us tell you more about PESCO Pumps and PESCO Engineering Service?

SEND FOR THIS BOOK **"Pressurized Power and Controlled Flow by PESCO". This book pictorially tells the story of PESCO equipment, manufacturing facilities and engineering service. A copy will be mailed promptly upon request.**

WRITE TO . . .
PESCO Products Co.
Industry Service F
11610 Euclid Avenue
Cleveland 6, Ohio

Division Borg-Warner

In Precision Hydraulics, Fuel Pumps, Air Pumps, Related Accessories . . .

PERFORMANCE POINTS TO Pesco FIRST

THESE 7 SOLUTIONS MAY SOLV[E] 700 OTHER PROBLEMS...

...perhaps your own

"BAKELITE" PLASTICS—Problem Solvers for Industry

When one manufacturer solves a wartime production problem by using the right BAKELITE plastic, the result may be helpful to many other manufacturers. In this spirit, we pass along here the solutions to seven typical problems, any one of which may provide the answer to yours. The plastic materials discussed are, of course, available only for highly essential uses.

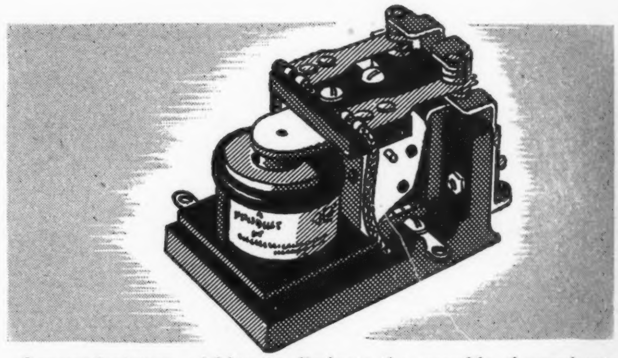
Do you have a tough coatings problem? In recent tests, steel panels coated with a BAKELITE resin primer showed no blistering, pimpling, or rusting after 8,000 hours of continuous water immersion, while other primers failed at 300 hours.

Does the molding of pieces thicker than 3/8 inches, using thermosetting materials, interest you? Heatronic molding, a recent development of the Bakelite Laboratories, makes this possible, speeds curing time 10 to 50 per cent, drops molding pressure 30 to 40 per cent.

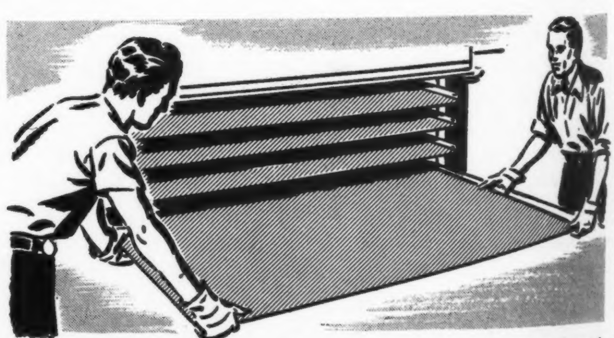
These examples are typical of the scores of developments you will be posted on if you keep in touch with Bakelite Plastics Headquarters. Our Engineering Staff and Development Laboratories have amassed a wealth of data that can help you now with your essential production problems, or with your plans for the days to come.

Write for specific technical literature. Please address Department 11.

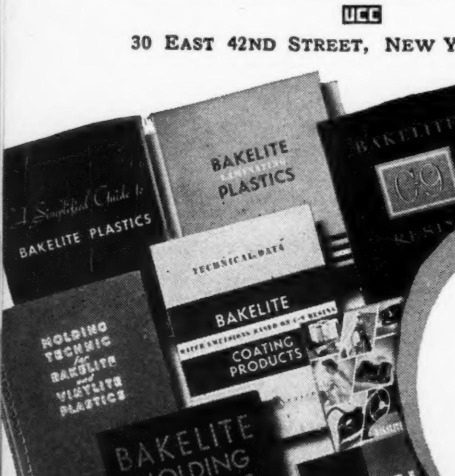
BAKELITE CORPORATION
Unit of Union Carbide and Carbon Corporation
UCC
30 EAST 42ND STREET, NEW YORK 17, N.Y.



A manufacturer, wishing to eliminate the assembly of several parts normally required in small relay construction, designed an improved relay for which the base and stationary contact support were to be molded in one piece. A BAKELITE general-purpose molding material was specified for this unusual and complex construction. This material provides the desired dielectric qualities and fine finish. It also withstands the severe vibration encountered in aircraft and shipboard installations, as well as salt atmosphere and wide temperature variations—from 60 deg. F. below zero to 180 deg. F. above.



Today, plywood can be made sturdy, durable, waterproof, and weather-resistant—with BAKELITE phenolic resin glue. Wartime applications, such as the plywood airplane and glider, Army truck bodies, and Navy PT boat sections have demonstrated these properties. Recently, carloads of BAKELITE phenol-bonded plywood were sent abroad to make pontoon bridges—stub-nosed boats that will float on rivers for months at a time, withstanding weathering and hard wear.



Useful Literature on Plastics

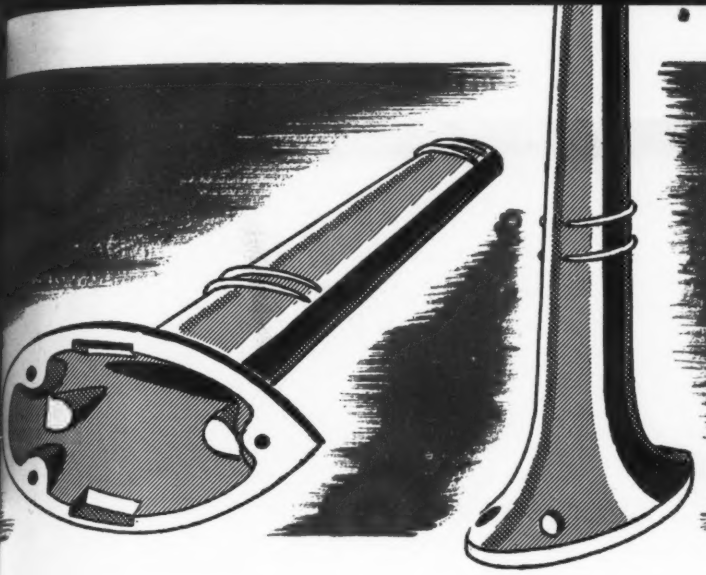
BOOKLET 11-A "BAKELITE HORIZONS"—This pamphlet provides a brief introduction to BAKELITE plastics. Describes the origin of plastics . . . their forms, fabricating techniques, and applications.

BOOKLET 11-P "A SIMPLIFIED GUIDE TO BAKELITE PLASTICS"—A 16-page, illustrated booklet that describes, in digest form, the various types of BAKELITE plastics and synthetic resin products.

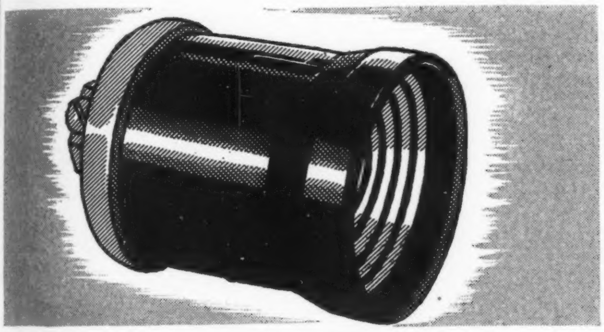
BOOKLET 11-M BAKELITE MOLDING PLASTICS"—A 32-page illustrated reference booklet. Gives technical descriptions of the various BAKELITE thermosetting and thermoplastic molding materials.

"MOLDING TECHNIC FOR BAKELITE AND VINYLITE PLASTICS" (Price $3.50)—A 224-page manual on the art of molding plastics. Contains latest technical data the designer, engineer, molder, and user should know about designing and fabricating hot-set and cold-set molding materials.

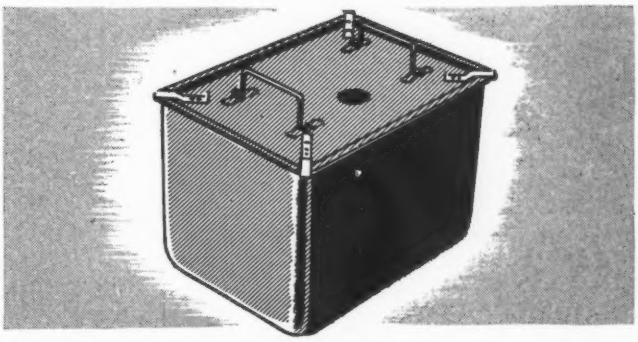
BOOKLET 11-L "BAKELITE LAMINATING PLASTICS"—A 24-page illustrated booklet. Describes, in detail, various



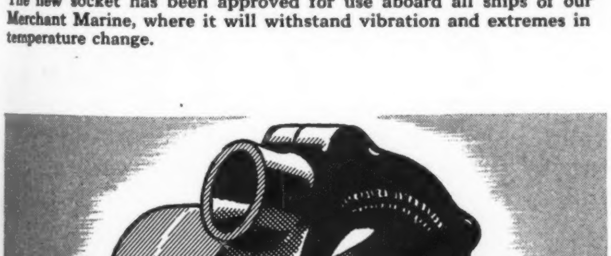
AN INTERESTING FEATURE of the huge Curtiss Commando troop-transport plane is its use of an extremely lightweight, yet tough and durable antenna and pitot tube, molded at low pressure using a BAKELITE laminating resin. To provide strength needed to withstand air pressures encountered in flight, the mast is molded in one piece, using a special "creped" cloth. Unlike conventional laminating cloth, this material, after it is impregnated with BAKELITE phenolic resin, is "creped" so that it can stretch in all directions in the molding process. Since the laminations remain intact, the finished mast has unusually high mechanical strength.



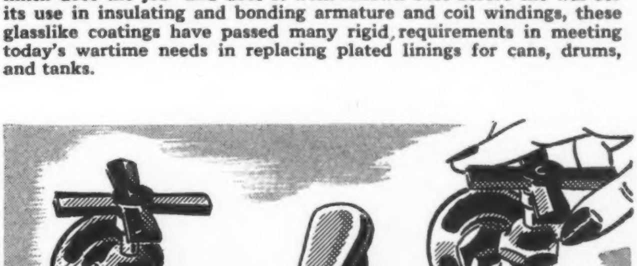
New, lighting fixture sockets aboard America's Victory Ships are molded of BAKELITE phenolic plastics. They are lighter, more compact, and more durable than sockets previously used. The manufacturer found that less breakage and faster assembly made possible a production jump of 10 to 15 per cent . . . pushed costs down 10 per cent. The new socket has been approved for use aboard all ships of our Merchant Marine, where it will withstand vibration and extremes in temperature change.



The lining of the food containers used in Medical Corps hospital food carts must stand up against constant scraping with ladle or spoon when serving, and sudden temperature changes on sterilizing. That's a tough assignment for any coating. Yet a BAKELITE resin baking finish does the job—and does it well. Known best before the war for its use in insulating and bonding armature and coil windings, these glasslike coatings have passed many rigid requirements in meeting today's wartime needs in replacing plated linings for cans, drums, and tanks.



A tiny blower measuring only four inches in diameter, weighing only four ounces, cools the radio and other electronic equipment on America's fighting aircraft. Using a BAKELITE general-purpose phenolic molding material, the manufacturer has been able to mold the lightweight blower housing to close tolerances, yet secure good heat resistance and mechanical strength.



Army, Navy. Federal housing developments, and Navy and Maritime ships are using plumbing accessories molded of BAKELITE cellulose acetate. Five hundred thousand faucet handles have already been produced—and are proving highly successful because of their low heat transmission, good heat resistance, fine appearance, and resistance to corrosion. Other developments include a shiny white elbow, for toilet flush tanks that will not shrink or distort in service.

types of laminated plastics made with BAKELITE laminating varnishes, and illustrates many applications. Outlines fabricating techniques, and gives ASTM data.

BOOKLET 11-V "BAKELITE HEAT-HARDENABLE VARNISH, ENAMEL, LACQUER, CEMENT" — A 40-page illustrated booklet. Describes resin-baking coatings and bonding materials—their properties, uses, and advantages.

BOOKLET 11-F "BAKELITE C-9 RESINS" —A 12-page illustrated booklet for the paint and varnish technologist. Shows how these new resins accelerate bodying time and improve performance of many surface coatings.

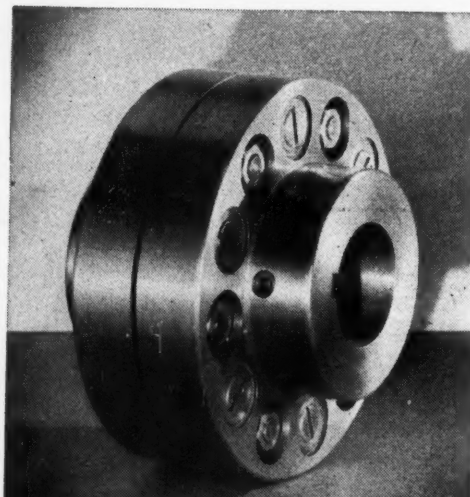
BOOKLET 11-J "BAKELITE COATING PRODUCTS" — A 4-page folder for the paint and varnish technologist, describing the new water emulsions based on C-9 resins.

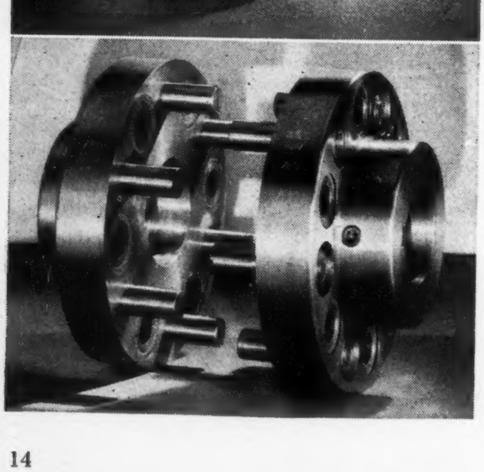
BOOKLET 11-Q "BAKELITE SEALING SOLUTIONS FOR POROUS CASTINGS" —A 4-page folder that tells how to reclaim porous and spongy castings by impregnating with resin-baking solutions.

BAKELITE

TRADE MARKS

Plastics Headquarters





We dare you...

Just take a couple of pencils right now and try to hold them in perfect alignment without touching each other while you count 10.

Remember that you are making this 10 second test with pencils weighing a fraction of an ounce. At the same time, remember that all the horsepower goes through the coupling connecting heavy machines running at high speed hour after hour.

Ajax Flexible Couplings have been doing this job for over 20 years. They do it without lubrication because of their rubber bushed, graphited-bronze bearings and interlocking drive studs.

Write for the facts on Ajax Flexible Couplings.

AJAX

ARMY E NAVY

Incorporated 1920

FLEXIBLE COUPLING CO.
WESTFIELD, N. Y.

MERCURY FLIES THE "Symbol of Leadership in the Cause of Freedom"

KIEKHAEFER CORPORATION

Awarded the ARMY-NAVY "E"

On October 30, 1943, Kiekhaefer Corporation was presented with the coveted Army-Navy "E." It is a symbol of excellence in war production—recognition of a vital, important contribution to the Nation. The Kiekhaefer Corporation is proud of this accomplishment, and proud of the workers who gave their wholehearted, patriotic co-operation to make it possible.

We accept the honor with humble pride, realizing that we have only endeavored to do our part in backing up the men at the front. But this is more than a war of guns and ammunition. It is also a war of equipment and materials, and America will win because she produces the best and most equipment for the best fighters in the world.

To the workers of the Kiekhaefer Corporation, this award is more than a symbol of achievement, it is an inspiration to put forth even greater effort in the future, to win, as quickly as possible, a just and lasting peace.

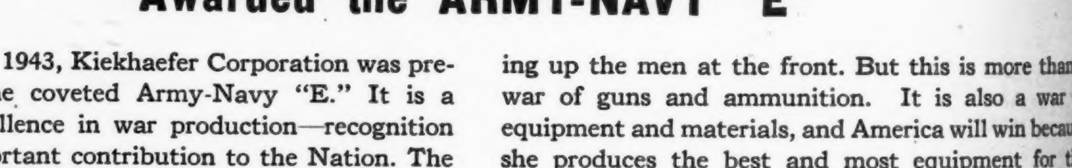
Kiekhaefer Mercury Two-cylinder Magnapull Starter Engine with Transmission.

MERCURY INDUSTRIAL AIR-COOLED ENGINES

Proved Veterans of War for Your Peacetime Products

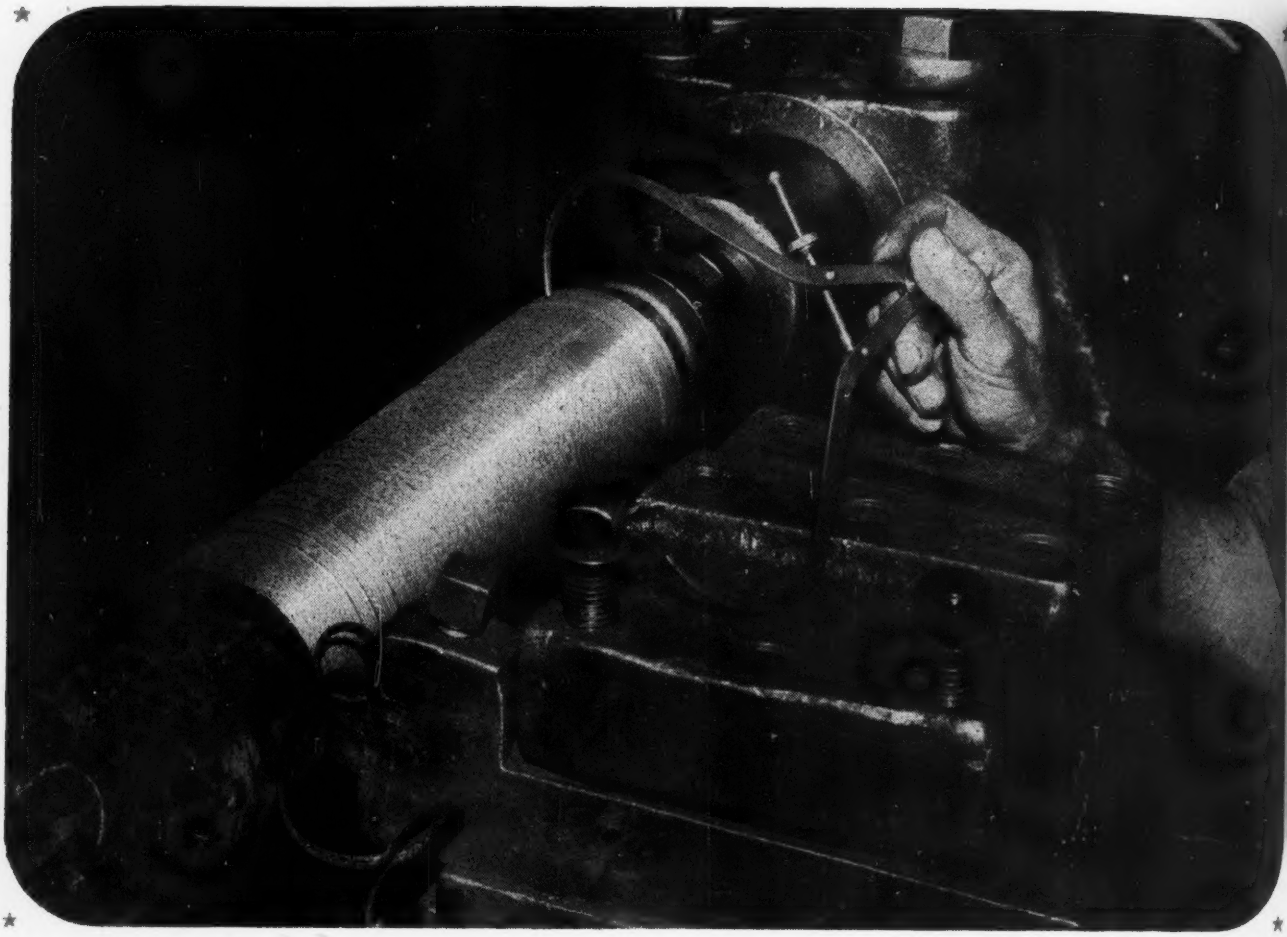
Mercury industrial, air-cooled engines, in military and defense work, are supplying dependable, portable power for compressors, pumps, electric generators, light plants, marine propulsion, chain saws, portable grinders and other portable tools. Their compact, space-saving design and quick-starting, cool-running, trouble-free performance are winning "service-stripes" in many vital war jobs. When peace comes Mercury Engines will be available to power your post-war products.

These are some of the vital war products powered by Kiekhaefer-built Mercury Industrial Air-cooled Engines.



KIEKHAEFER CORPORATION

Industrial Air Cooled Engines CEDARBURG, WISCONSIN **Outboard Motors**



DBL High Speed Steel HAS SET RECORDS . . . NOW HERE'S *Super DBL!*

DEVELOPED ESPECIALLY FOR YOUR HEAVY-CUT FAST-FEED, HARD AND *Tough Jobs!*

THIS is the next step in Allegheny Ludlum metallurgical development of the DBL low-tungsten molybdenum analysis. *Super DBL* is the DBL analysis with the addition of cobalt, and it develops the maximum red hardness—the same *extra margin* of cutting quality—that you were formerly accustomed to get in a tungsten cobalt steel as compared to 18-4-1.

Super DBL has been thoroughly tested and proved. In performance, as well as in the conservation of vital alloys, it meets the needs of the times. You'll find it an ideal selection for heavy duty tools—especially suited for roughing or hogging work on hard, gritty materials, such as cast iron and steel; or on tough materials like heat treated alloy and stainless steels. There is nothing special in its heat treating or handling requirements. ● Available *now*—in standard forms and finishes, and in mill-treated toolholder bits—from Allegheny Ludlum and distributor's warehouse stocks, coast to coast.

AL STEEL FOR THE NATION'S WELFARE

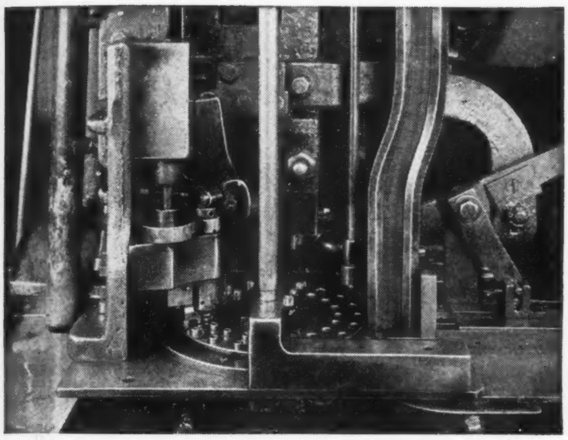
Allegheny Ludlum
STEEL CORPORATION
BRACKENRIDGE, PENNSYLVANIA

A-9073 . . . W&D


standardizing Your Bolts?
Let R B & W engineers help you check your present bolt and nut specifications according to the simplification program suggested by OPA and other war agencies. Quite likely you can include more "standards," more "stock sizes" without loss of holding power... relieve catalog and stocking confusion. RB&W has helped many firms avoid production delays and the expense of many small orders. Write us.
futurizing
BOLT-SHAPED METAL PART
After the war, RB&W's Research and Experimental Shop, now devoted to problems of military equipment, will again be at your service. If your product's design includes a metal part with bolt-shaped characteristics, we can make it for you by upsetting at a fraction of machining cost. RB&W cold headers, working even to aircraft tolerances, have made tremendous savings possible for many firms... will be ready to assist your *post-war* designing.
BOLTS EMPIRE NUTS·RIVETS
and Allied Fastening Products ... Since 1845
RB&W
RUSSELL, BURDSALL & WARD BOLT & NUT COMPANY
Factories at Port Chester, N. Y., Rock Falls, Ill., Coraopolis, Pa.
Sales offices at Philadelphia, Chicago, Detroit, Chattanooga, Los Angeles, Portland, Seattle
Making strong the things that make America strong

better Methods

that supplant hand labor



A locating device that turns bushing joints away from the bearing point as chain belts are assembled.

It has been estimated that the power used in machinery produces twelve times as much as *all* human labor could produce without it. At Baldwin-Duckworth you will find many machines that supplant hand labor, and at the same time provide *better* chain belt drives. One of them is this locating device. Attached to an assembly press it automatically turns bushings so that joints are away from the bearing point—resulting in an improved chain belt.

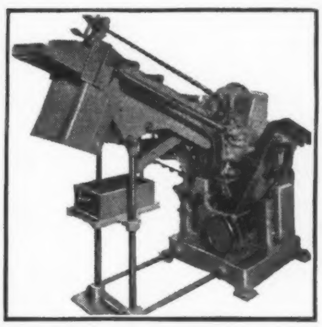
better Drives with Baldwin Roller Chain Belts

The use of Baldwin roller chain belts simplifies and improves the design of many machines. They absorb shock loading without measurable loss of power—transmit exact speed ratios for accurate timing—operate at virtual 100% efficiency.

The Baldwin catalog gives you data on standard chain belt application. For specialized applications on any machine you may be converting, designing or redesigning, a Baldwin man will gladly counsel you.

BALDWIN-DUCKWORTH Division of Chain Belt Company, 320 Plainfield Street, Springfield, Mass.

EXAMPLE



This clip loader for the famous Garand rifle is an important behind-the-lines war machine. Baldwin Roller Chain Belts give it:

1. Split-second timing
2. Smooth, jerk-free operation
3. Virtually 100% efficiency

IT'S BALDWIN-EQUIPPED

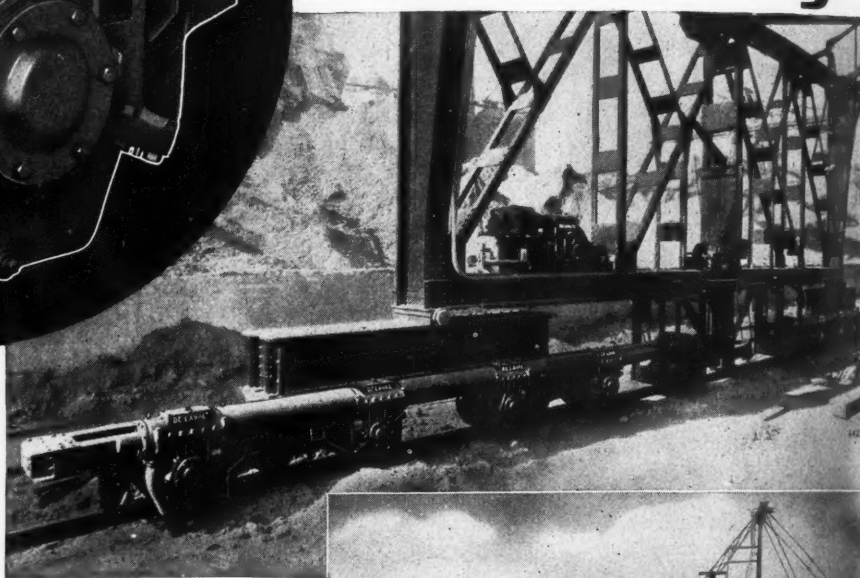
better **Drives** through better **Methods**

BALDWIN

ROLLER CHAIN BELTS

DE LAVAL GEARS

Specified for Second Ore Bridge



This 10-ton ore bridge is propelled along the waterfront by four 33-h.p. motors driving the individual traction wheels through 32 De Laval 40-ratio Worm Gears. There are also two 8½-h.p. motors operating clamping drives through De Laval 24½-ratio Worm Gears.

The ore bridge here illustrated, built in 1937, was equipped with *DE LAVAL WORM GEARS*. These gears have given such reliable and excellent service, that when a duplicate ore bridge was recently ordered De Laval gears were again selected.

DE LAVAL gears are widely used on blast furnace and steel mill equipment, including billet pushers, catcher tables for three-high mills, coal crushers, cooling table transfers, crane trolleys, draw benches, edging rolls, fan drives, furnace door lifters, hot beds, heavy-duty roll lathes, ingot buggy drives, manipulator tables, piler tables, plate shears, roll grinders, screw-downs, steel wire fabricating machines, straighteners, up-cut bloom shears, etc.

De Laval worms and gears are supplied either separately or complete with bearings and casings. Our engineers will gladly assist in solving transmission problems.

Ask for Publication W-1135.

DE LAVAL **WORM GEAR DIVISION**

of the De Laval Steam Turbine Co., Trenton, N. J.

MANUFACTURERS OF TURBINES STEAM, HYDRAULIC PUMPS CENTRIFUGAL PROPELLER ROTARY DISPLACEMENT MOTOR-MOUNTED, MIXED-FLOW CLOGLESS, SELF PRIMING CENTRIFUGAL BLOWERS and COMPRESSORS GEARS WORM, HELICAL and FLEXIBLE COUPLINGS

BEST SPRING TRICK OF THE WAR

. . . CRAMMING A FIELD GUN INTO A TANK TURRET

THE tough problem here was to reduce gun recoil from feet to a matter of inches. But it was accomplished. Today, specially designed springs of special alloy steel that function perfectly in sharply reduced space, safely absorb the recoil wallop of the hard-hitting tank guns that jolt the Axis everywhere.

From these massive tank-gun springs to the tiny springs that arm explosive shells with a deadly precision that assures a burst at the touch of a silk parachute, our spring specialists have solved one problem of spring design after another. The same high standards of spring engineering are behind the reliable performance of every type of American fighting equipment for which we have designed and produced springs by the millions.

If you use springs, we can help you. Our spring engineers bring to your problems more than an expert knowledge of springs. Their intimate understanding of the wartime steels now available can be especially helpful in meeting the involved and difficult requirements that today face the spring designer.

U·S·S American Quality Springs

AMERICAN STEEL & WIRE COMPANY

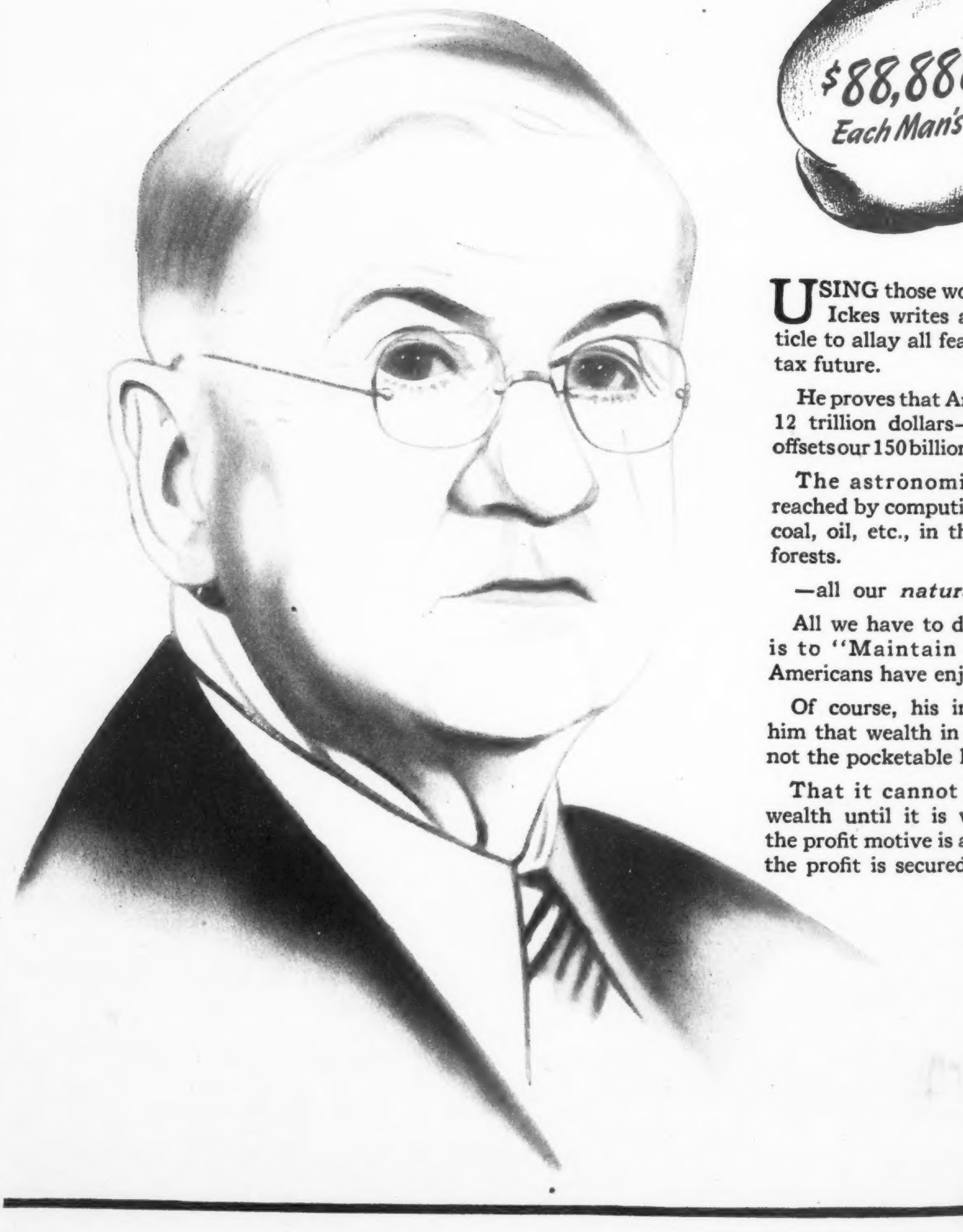
Cleveland, Chicago and New York

Columbia Steel Company, San Francisco, *Pacific Coast Distributors*
United States Steel Export Company, New York

UNITED STATES STEEL

—then he said to himself

"We are every one a Croesus"



USING those words, Multi-Job Ickes writes a magazine article to allay all fears of a terrible tax future.

He proves that America is worth 12 trillion dollars—which neatly offsets our 150 billion debt (to date).

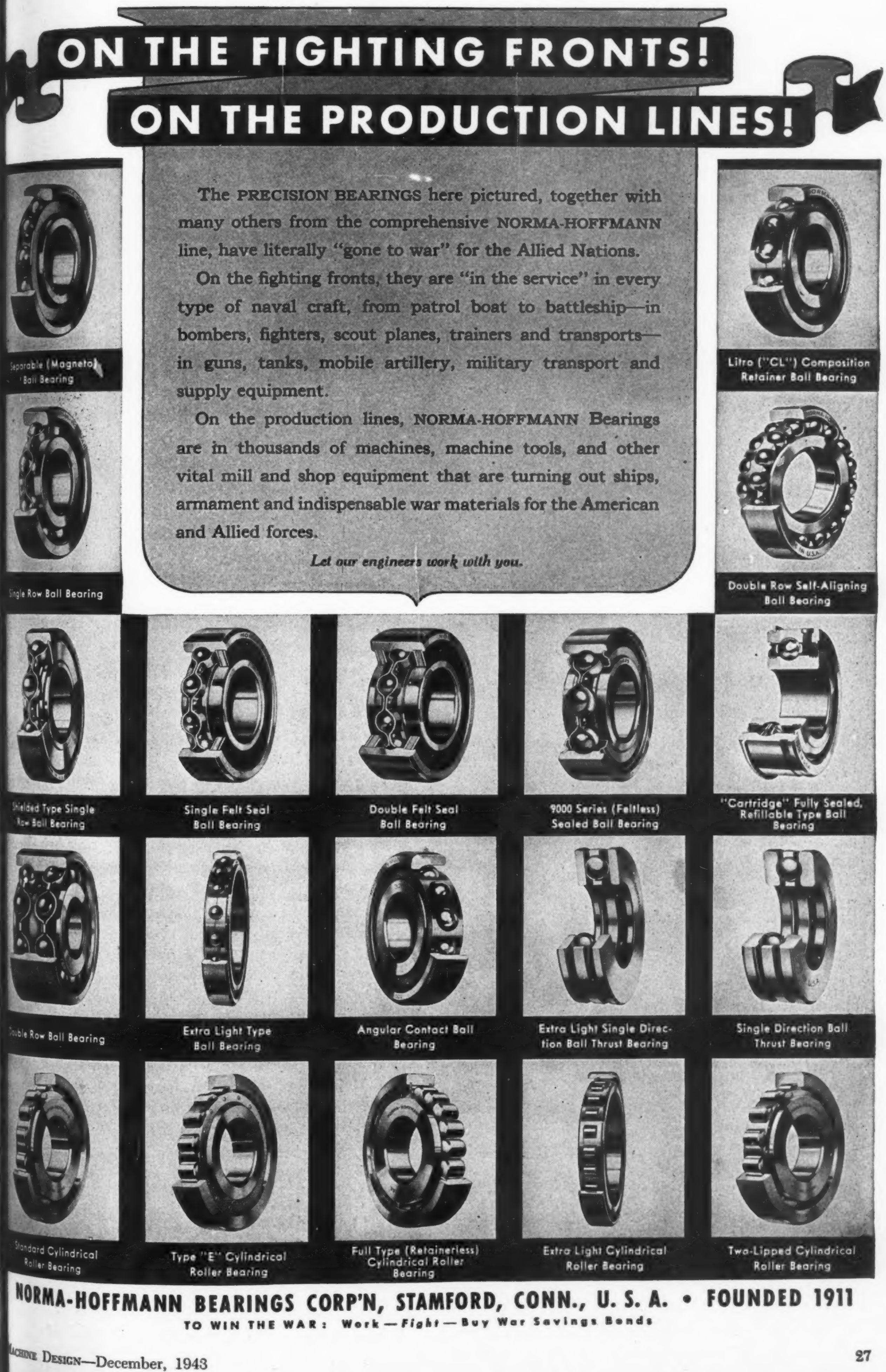
The astronomical figure is reached by computing all the iron, coal, oil, etc., in the ground and forests.

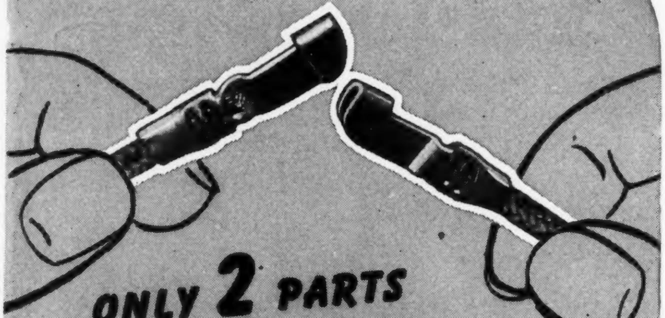
—all our *natural resources*.

All we have to do to pocket it is to "Maintain the freedom Americans have enjoyed."

Of course, his inner self tells him that wealth in the ground is not the pocketable kind . . .

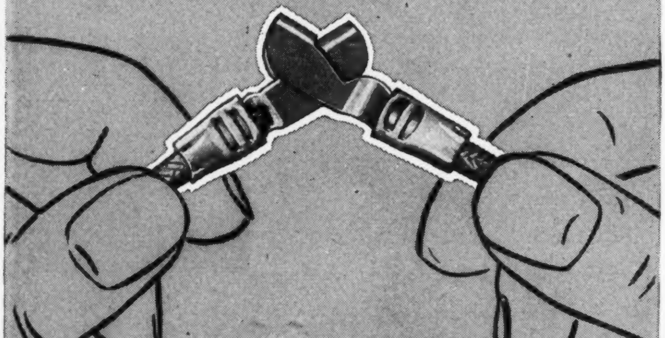
That it cannot become real wealth until it is worked—until the profit motive is applied—until the profit is secured.


ON THE FIGHTING FRONTS!
ON THE PRODUCTION LINES!
The PRECISION BEARINGS here pictured, together with many others from the comprehensive NORMA-HOFFMANN line, have literally "gone to war" for the Allied Nations.
On the fighting fronts, they are "in the service" in every type of naval craft, from patrol boat to battleship—in bombers, fighters, scout planes, trainers and transports—in guns, tanks, mobile artillery, military transport and supply equipment.
On the production lines, NORMA-HOFFMANN Bearings are in thousands of machines, machine tools, and other vital mill and shop equipment that are turning out ships, armament and indispensable war materials for the American and Allied forces.
Let our engineers work with you.
Separable (Magneto) Ball Bearing
Litro ("CL") Composition Retainer Ball Bearing
Single Row Ball Bearing
Double Row Self-Aligning Ball Bearing
Shielded Type Single Row Ball Bearing
Single Felt Seal Ball Bearing
Double Felt Seal Ball Bearing
9000 Series (Feltless) Sealed Ball Bearing
"Cartridge" Fully Sealed, Refillable Type Ball Bearing
Double Row Ball Bearing
Extra Light Type Ball Bearing
Angular Contact Ball Bearing
Extra Light Single Direction Ball Thrust Bearing
Single Direction Ball Thrust Bearing
Standard Cylindrical Roller Bearing
Type "E" Cylindrical Roller Bearing
Full Type (Retainerless) Cylindrical Roller Bearing
Extra Light Cylindrical Roller Bearing
Two-Lipped Cylindrical Roller Bearing
NORMA-HOFFMANN BEARINGS CORP'N, STAMFORD, CONN., U. S. A. • FOUNDED 1911
TO WIN THE WAR: Work—Fight—Buy War Savings Bonds



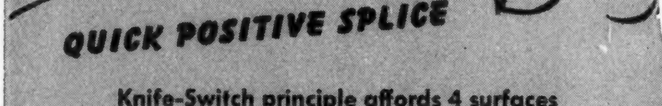
ONLY 2 PARTS BOTH IDENTICAL

Eliminates stocking more than one item. Incorporates AMP Diamond Grip Insulation Support features.



QUICK POSITIVE SPLICE

Knife-Switch principle affords 4 surfaces of direct contact to assure maximum conductivity through the coupling.



STAYS TOGETHER UNTIL INTENTIONALLY TAKEN APART

Tensile strength of splice is greater than that of the wire itself, yet assembly is easily and quickly uncoupled when desired.

CONTOUR OF ASSEMBLY FIRMLY HOLDS INSULATION TUBING

With the tubing in place the splice cannot be accidentally disconnected.

A-MP

Solderless

SPLICING TERMINAL

With *Diamond Grip* INSULATION SUPPORT

1. Unique locking principle using only 2 identical parts — no third part to stock or lose.

2. Four-point "Knife-Switch" wiping action assures minimum contact drop through the coupling, and gives a perfect electrical connection even under adverse conditions.

3. AMP Diamond Grip insulation support gives maximum protection for insulation at wire end of connection.

"PRECISION ENGINEERING APPLIED TO THE END OF A WIRE"

4. Cannot be uncoupled by pull on the wire — tensile strain on the wire tends to further engage the coupling.

5. Visual inspection after assembly. Wire goes through the barrel of the splicing terminal, insuring against possibility of wire being only partly inserted in the barrel.

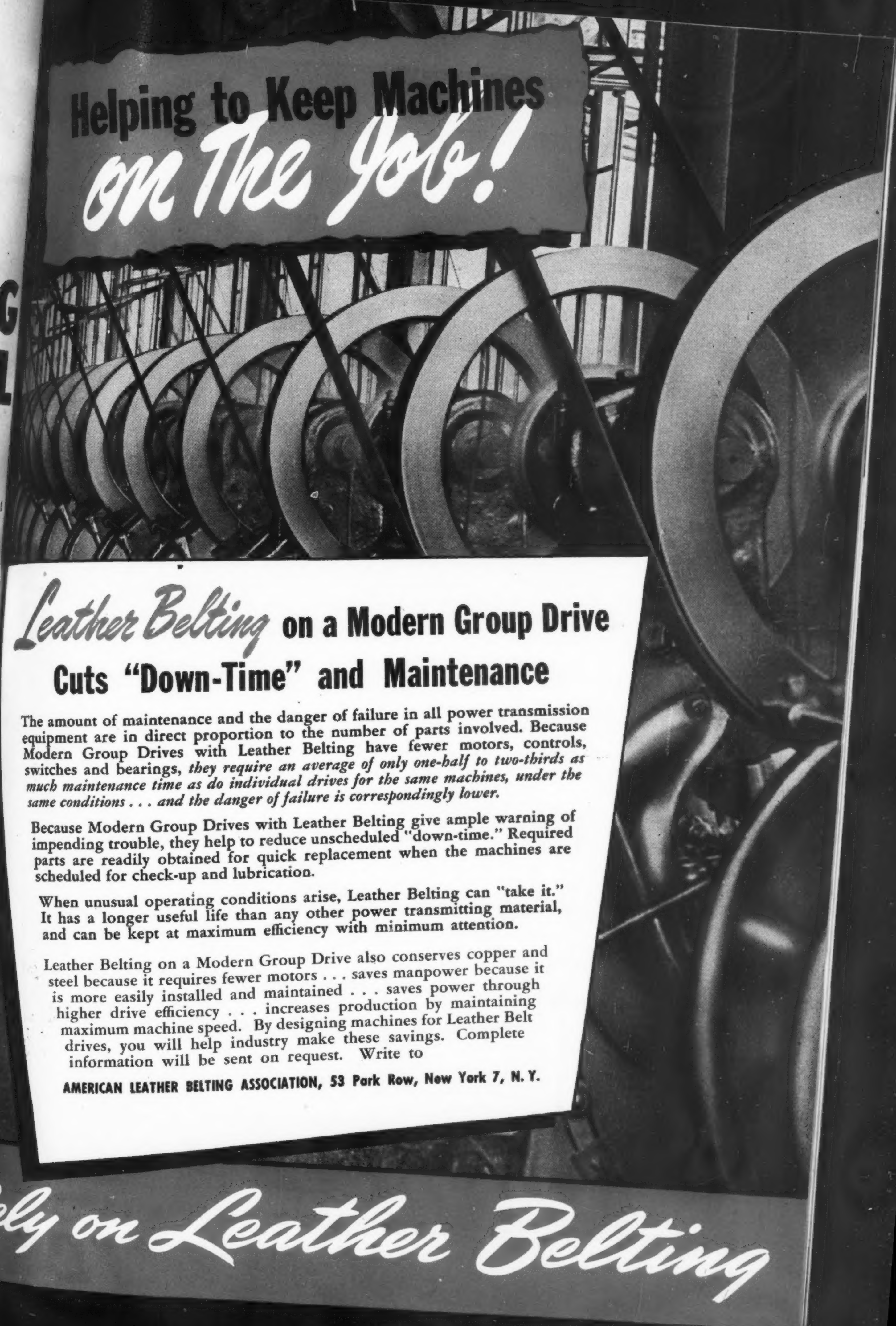
6. Makes a connection which will withstand any but the most excessive abuses in service. Flexible copper and simple construction permit easy return to original shape if distorted in service.

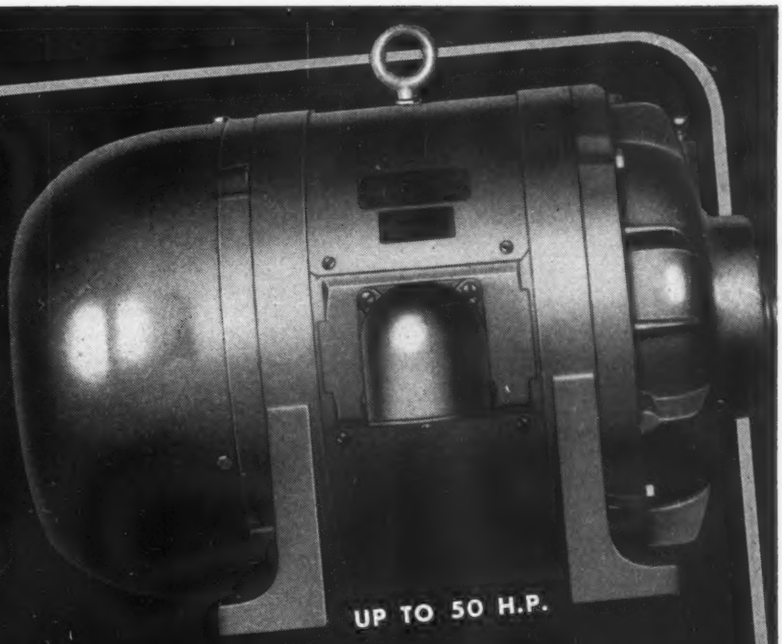
7. Insulation sleeving slips over entire assembly with ease. A fairly loose insulation sleeve expands to clasp oval formation of entire assembly — to remain firmly in place until removal.

8. Offset tongue acts as wire stop, preventing the insertion of the wire to a point where it would interfere with the coupling.

9. AMP crimping tools make all three crimps in one operation.

AIRCRAFT-MARINE PRODUCTS INC.
1521-37 N. FOURTH ST.
HARRISBURG, PENNA.
TELEPHONE: HARRISBURG 4-0101
Canadian Representative: A & M ACCESSORIES, LTD., TORONTO, CAN.


Helping to Keep Machines
on The Job!
Leather Belting on a Modern Group Drive
Cuts "Down-Time" and Maintenance
The amount of maintenance and the danger of failure in all power transmission equipment are in direct proportion to the number of parts involved. Because Modern Group Drives with Leather Belting have fewer motors, controls, switches and bearings, *they require an average of only one-half to two-thirds as much maintenance time as do individual drives for the same machines, under the same conditions . . . and the danger of failure is correspondingly lower.*
Because Modern Group Drives with Leather Belting give ample warning of impending trouble, they help to reduce unscheduled "down-time." Required parts are readily obtained for quick replacement when the machines are scheduled for check-up and lubrication.
When unusual operating conditions arise, Leather Belting can "take it." It has a longer useful life than any other power transmitting material, and can be kept at maximum efficiency with minimum attention.
Leather Belting on a Modern Group Drive also conserves copper and steel because it requires fewer motors . . . saves manpower because it is more easily installed and maintained . . . saves power through higher drive efficiency . . . increases production by maintaining maximum machine speed. By designing machines for Leather Belt drives, you will help industry make these savings. Complete information will be sent on request. Write to
AMERICAN LEATHER BELTING ASSOCIATION, 53 Park Row, New York 7, N. Y.
Rely on Leather Belting



Dynamic Balance IS PAYING OFF FOR DELCO MOTOR USERS

With production machines on a 24-hours-a-day hitch, many a plant engineer is patting himself on the back for specifying Delco motors.

The reason for these self-congratulations (as if any plant engineer had time for them these days) is that all Delco motors are *dynamically balanced* to cut down vibration. That means less wear on motor bearings and parts—less wear on machines—more permanent mounting and alignment—and greater accuracy in machining operations.

On top of this, Delco motors are demonstrating the advantages of precision shaft-bearing fits that are measured in tenths of thousandths, insulation that can "take it" for years on end, and cool-running design that makes the most of ventilation and heat dissipation.

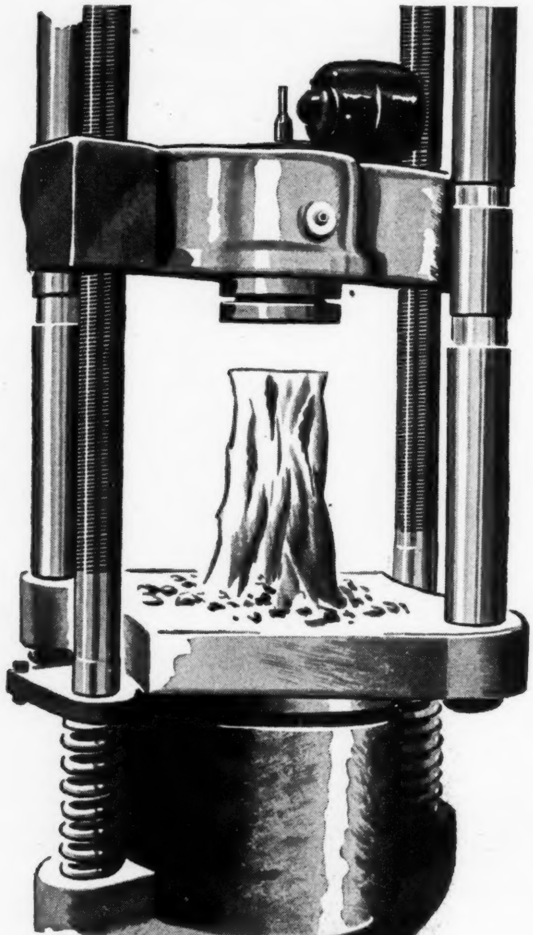
From end frame to end frame, Delco motors are built to do the job.

GO "LONG" ON BONDS AND SHORTEN THE WAR

DELCO MOTORS

DELCO PRODUCTS DAYTON, OHIO

DIVISION OF GENERAL MOTORS CORPORATION



THE

"BLOCK BUSTER" MACHINE

and what Hele-Shaw Fluid Power had to do with it—

Not so long ago, machines for breaking test blocks of concrete, wood and other materials were essentially weighing devices, mechanically operated.

Someone conceived the idea of using hydraulic rams for exerting the tremendous pull or push required. The first rams were pumped by hand, but during the natural course of improvement, our engineers were approached for suggestions. They recommended a Hele-Shaw Pump and controls.

Several important advantages were gained. The Hele-Shaw Pump, being a rotary radial piston type, applied the power smoothly and continuously. Through comparatively simple controls, the rate of flow of the oil under pressure could be regulated to obtain quickly any desired rate of travel of the ram . . . and automatically maintain it.

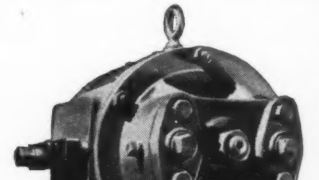
With the oil fluid medium, the pump could be located at any convenient point, not necessarily on the testing machine. The test load could be read directly from hydraulic gauges.

Many types of hydraulic testing machines are now powered by the fluid muscles of Hele-Shaw Pumps. Possibly you, too, have a profitable application for Hele-Shaw Fluid Power in your post-war planning. If you *think* so, put your product or process, machine operation or control up to Hele-Shaw engineers.

THE

Hele-Shaw

Fluid Power Pump



ÆCO 75th ANNIVERSARY

OTHER A-E-CO PRODUCTS: TAYLOR STOKERS, MARINE DECK AUXILIARIES, LO-HED HOISTS

AMERICAN ENGINEERING COMPANY

2502 ARAMINGO AVENUE • PHILADELPHIA, PA.

REPORTING *on the use of* *Linde Methods* *in mass production..*

METAL FABRICATING ··· *if you work with metals, you should know more about these Linde Methods for* "Carpentry in Steel."

In this picture, a Unionmelt electric welding machine is joining automatically the edges of steel plate being fabricated into a pressure vessel . . . making uniformly strong welds . . . at high speed. Other Unionmelt machines . . . mounted on light, overhead cranes . . . are working on semi-finished structures further down the line.

Unionmelt welding was developed by The Linde Air Products Company. Other Linde methods . . . the "flame" methods . . . are also important to the complete picture of joining metals. Oxy-acetylene steel welding, bronze-welding, copper welding, pressure-welding, silver brazing, and other joining techniques . . . whether manually applied or mechanized . . . all have a place in the mass construction of equipment of many sizes and kinds.

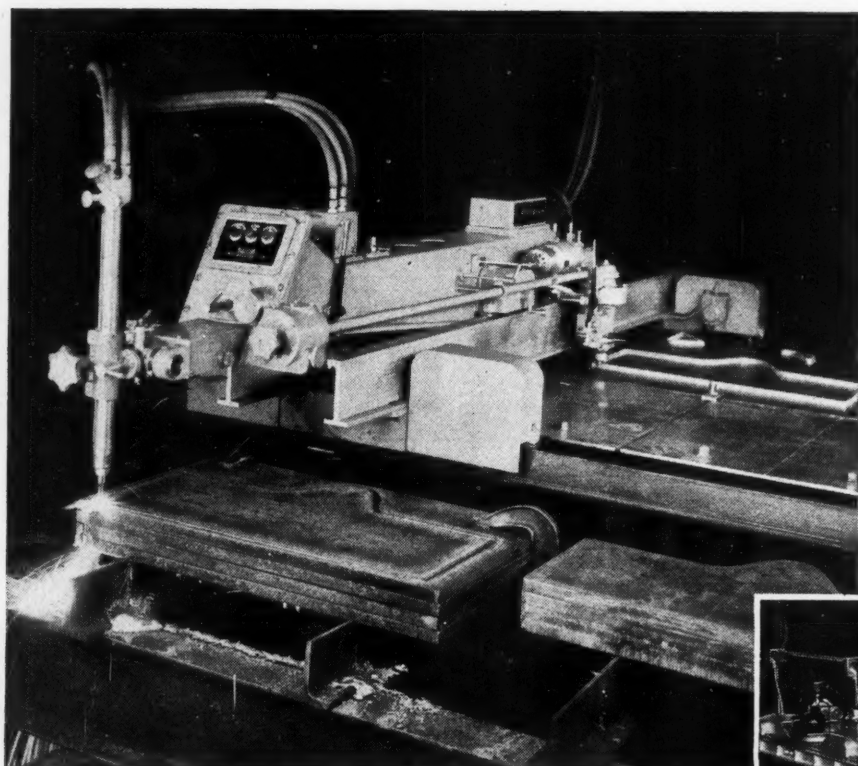
Mass production is truly a job of "carpentry in steel." Metals must be cut to size and shape . . . bent . . . formed . . . treated . . . for final fabrication. In all of these operations, Linde-developed flame processes are importantly employed.

Some applications of these flame processes are shown in the following pages. Review of them suggests the importance of keeping posted on *all* of Linde's advances in oxy-acetylene flame-fabrication . . . and of using productively, without waste, all supplies for these efficient metalworking methods.

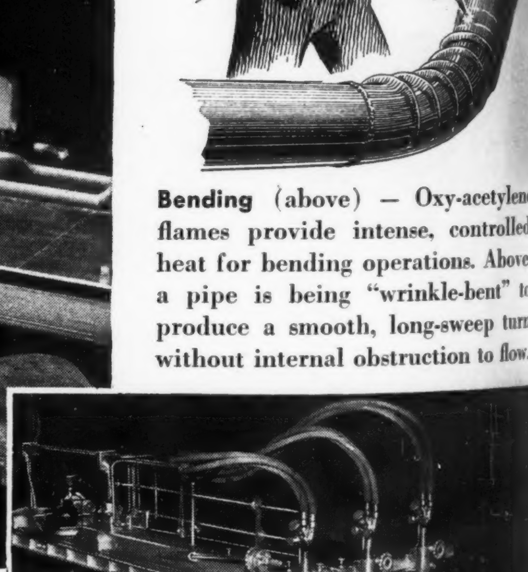
In the Fabrication
of STEEL EQUIPMENT

Linde Methods save Time, Power, and Materials . . .

A large part of the specialized mass production work of today is done faster, better, and at less cost by oxy-acetylene flame-techniques such as those shown here. The engineering facilities of The Linde Air Products Company helped industry to adapt these peacetime developments in efficient metalworking for today's needs. This quick review will help you to remember them . . . for tomorrow.

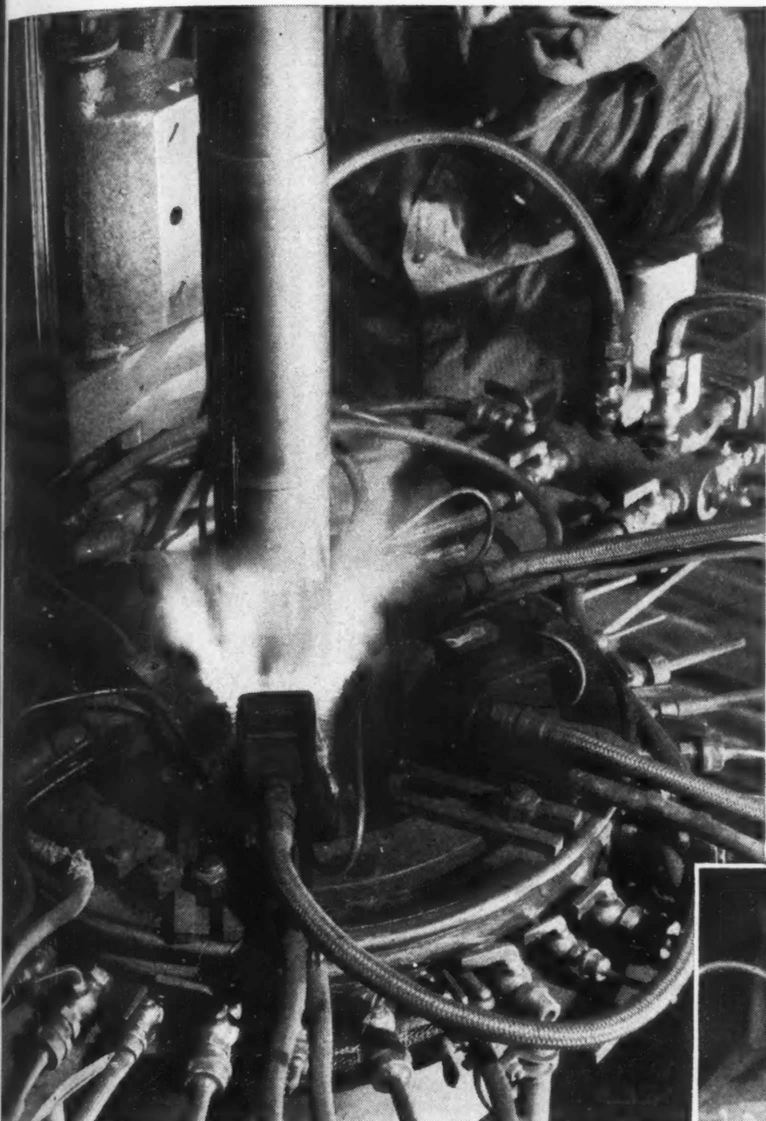


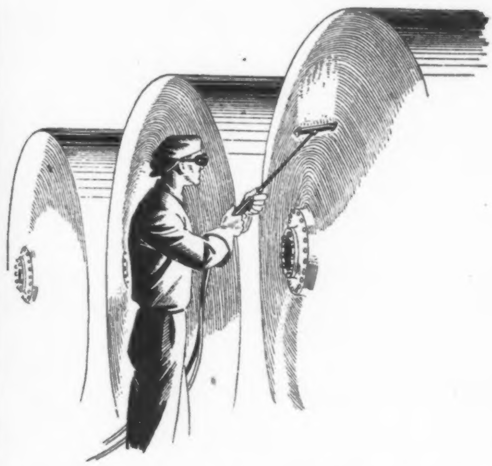
Bending (above) — Oxy-acetylene flames provide intense, controlled heat for bending operations. Above, a pipe is being "wrinkle-bent" to produce a smooth, long-sweep turn without internal obstruction to flow.



Oxy-Acetylene Flame-Cutting is a quick, "one-pass" method for shaping steel . . . in straight lines, circles, or irregular contours. Flame-cut edges are clean and smooth . . . often require no machining before use. Flame-cutting is done both with manually operated blowpipes, and with stationary or portable cutting machines. By flame-cutting, one-of-a-kind orders are easy to make up . . . design changes are simplified . . . and change-overs from parts of one shape to another require only a few minutes. In the illustration above, an Oxweld flame-cutting machine is "stack-cutting" four parts simultaneously. Shown at the right are other applications of flame-cutting.

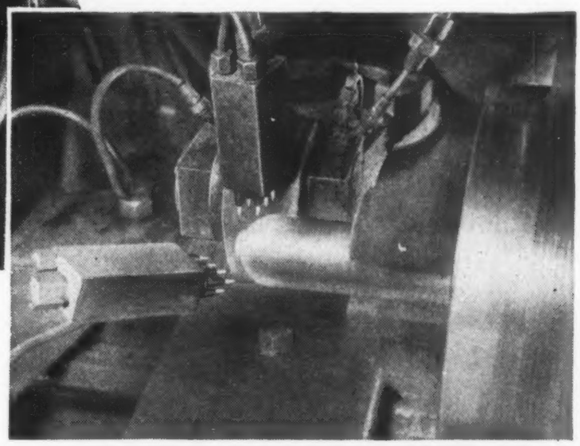
Multiple-Cutting—In some cases, when it is desired to produce numerous identical parts, several blowpipes . . . guided by a single templet . . . are mounted on the flame-cutting machine to cut simultaneously.



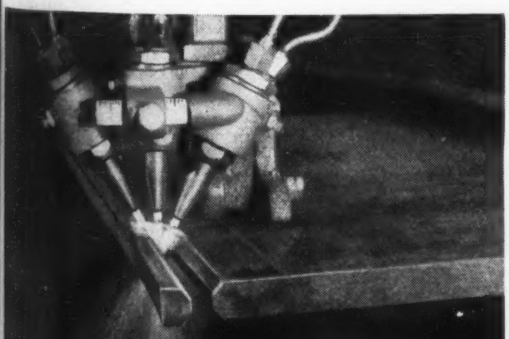


Flame-Priming (above)—Oxy-acetylene flame-priming of steel prior to painting removes loose scale, rust, moisture, oil, and grease. Paint applied to the still-warm surface bonds tighter and dries faster.

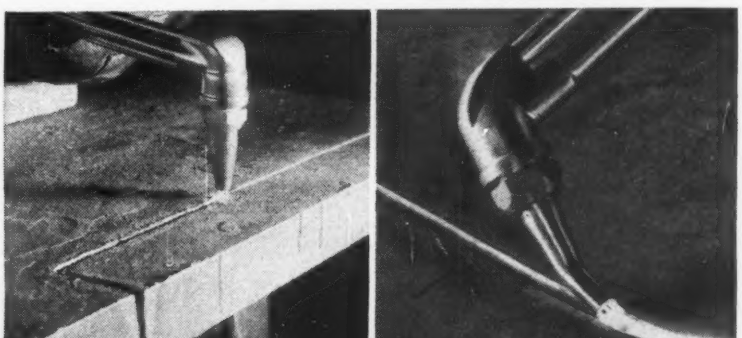
Flame-Spinning (below) — This flame-method for forming steel is used for such work as end-closure of tubing to eliminate deep-drawing operations.



Flame-Hardening (above)—Oxy-acetylene flame-hardening imparts a hard case to steel and iron parts without affecting the toughness of the core. Parts can thus be made of less costly base metals selected for core properties, and then protected against wear by flame-hardening surface areas.

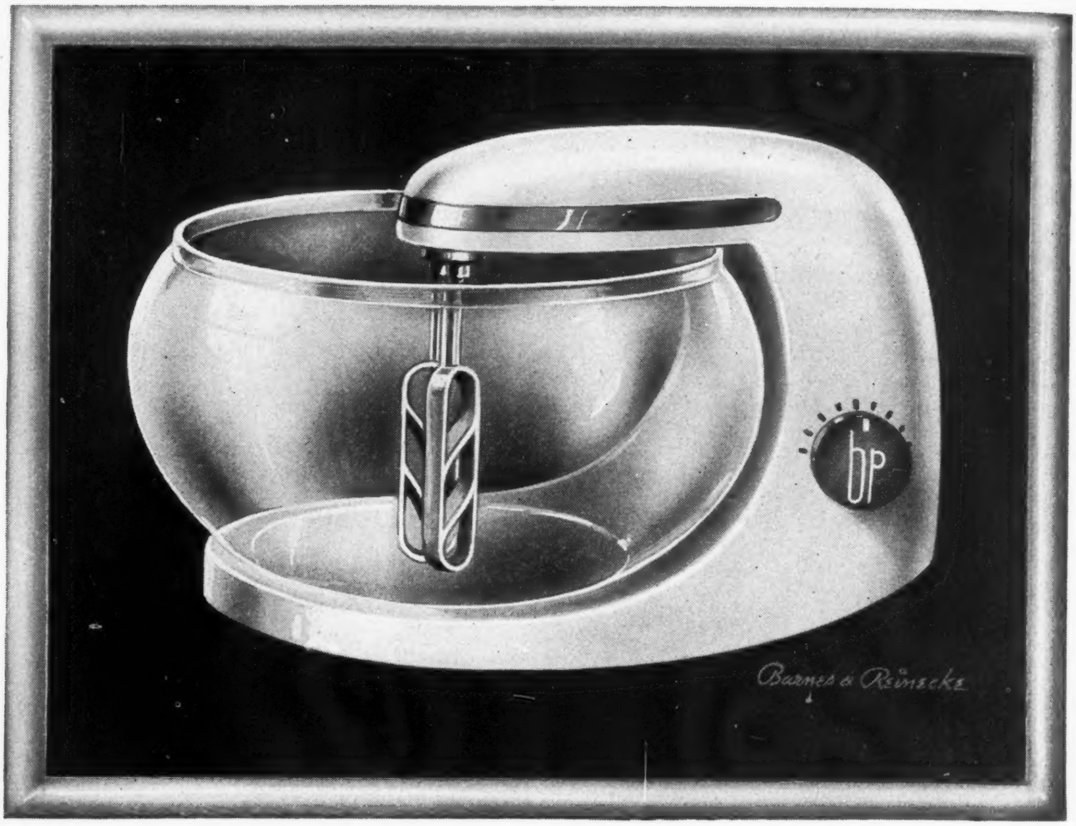


Flame-Planing—Mechanized flame-cutting in several planes simultaneously is a quick and economical way to prepare plate edges for welding. Accuracy of the cuts is comparable to results obtained by using more costly, mechanical methods.



Hand-Operated Cutting Blowpipes (above) are useful for many jobs. When used with gouging nozzles (above, right), a groove can be made quickly in a metal surface.

For more information on Linde methods, please turn the page.



Tomorrow's MOLDED PLASTIC JOB

Success story . . . in the making

This is an industrial designer's conception of a post-war product in molded plastic. Think of it, for a moment, as your product . . . as a picture of an idea with which you hope to capture tomorrow's market. . . . So far, so good.

But, (and this is most important) the translation of this idea into reality . . . the ultimate success of your product . . . depends upon your choice of custom molder. Because your molder's function consists of sweating through the engineering work (both from molding and end-use viewpoints), meshing this with his knowledge of the myriad plastic materials . . . and then building the molds, running the job, finishing each part as required, and feeding it into your production lines as your schedule demands. Full responsibility, which should be based on proven ability.

Here at CMPC our presses are filled with war work, but we're planning future products with many manufacturers who are aware of the tremendous advantages of getting the jump on competition. We are working with them (as we will with you) in both design and engineering. We're giving sound, unbiased advice on the selection of molding materials. Then, when the great day comes, the spade work will be done, and we will assume full responsibility for every operation—mold making, molding, and finishing.

If you're planning plastics, you'll find a friendly, interested understanding of your problems here, a coast-to-coast reputation for quality production, and the largest and best equipped custom molding plant in the Middle West. Ask for a CMPC development engineer. There's no obligation.

CHICAGO MOLDED PRODUCTS CORPORATION

Precision Plastic Molding

1028 NORTH KOLMAR AVENUE, CHICAGO 51, ILLINOIS

COMPRESSION, INJECTION, AND TRANSFER MOLDING OF ALL PLASTIC MATERIALS

They pioneered on the Santa Fe Trail
—and America is STILL pioneering.

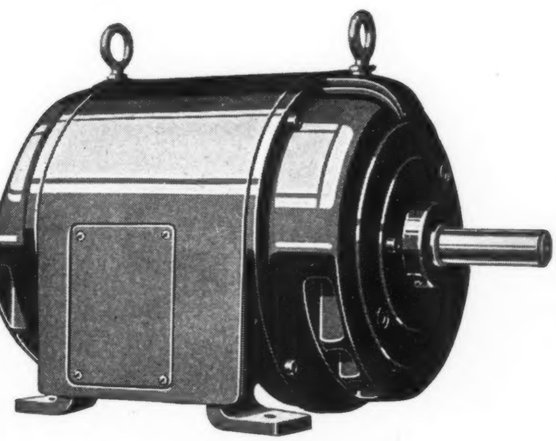
PIONEERS!

Since the days of line shafts, wooden pulleys and dangling belts, Reliance has pioneered in the *application* of electric motor-drive.

Cooperating with machine designers, Reliance engineers have been able to eliminate transmission gadgets—gears, brakes, clutches, belts, couplings—and have made power control exceedingly simple, easy and effective.

The results: lower-priced, better-performing, more salable machines; and, for machine users, stepped-up production with better quality at lower cost.

All Reliance salesmen are Engineers and Pioneers . . . engineers who know electric motors and motor-drive; pioneers, not afraid to tackle something new. Send for one if you need practical, helpful suggestions.



Reliance A-c. Squirrel-cage Motor. Simple, quiet and rugged. THE WORK-HORSE OF INDUSTRY.

RELIANCE A-C D-C MOTORS

RELIANCE ELECTRIC & ENGINEERING CO.

1088 Ivanhoe Road • Cleveland, Ohio

Birmingham • Boston • Buffalo • Chicago • Cincinnati • Detroit • Greenville (S.C.) • Los Angeles • New York
Philadelphia • Pittsburgh • Portland (Ore.) • St. Louis • Salt Lake City • San Francisco • Syracuse • other principal cities.

Proved for you . .

IN TOUGH HEAVY-DUTY SERVICE

Full speed ahead to full reverse in 3 seconds . . . *no other clutch could do it!*

This tug—typical of hundreds of Navy and Merchant Marine vessels—is proving every day that the Fawick Airflex Clutch handles heavy service jobs with entirely new standards of efficiency and economy.

The Fawick Airflex Clutch protects both prime mover and driven member against shock, strain and vibration—through controlled air pressure. No moving parts, no arms, levers or toggles, no lubrication required. Maintenance costs very low. Operates as clutch, brake, slip clutch or flexible coupling.

For any heavy-duty application—on any machine—send us details and we'll gladly recommend the Fawick Clutch or Brake that best fills the need.

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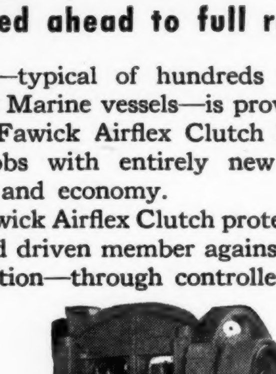
9919 Clinton Rd. Cleveland 11, Ohio
In Britain, Crofts Engineers, Ltd., Bradford, England



For All Heavy Machinery

On Punches, Shears, Turbines and severe-duty drives, Fawick Airflex Clutches and Brakes are compact, silent, smooth and shock-free. They slip readily under overloads and save on power.

12 IMPORTANT ADVANTAGES

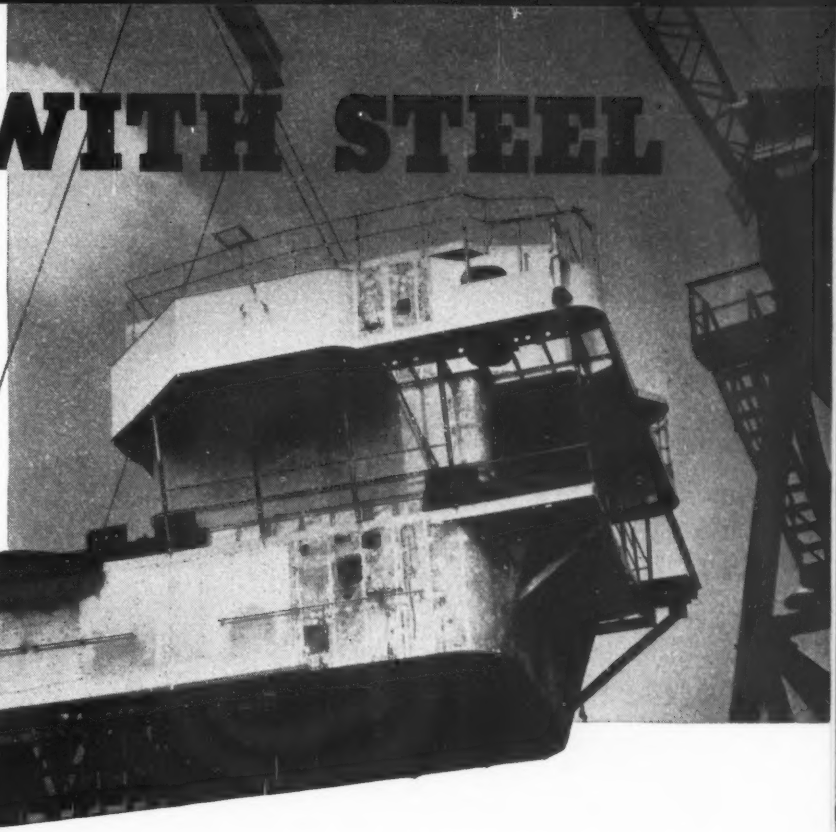
1. Simple in design and operation.
2. Flexible control by air.
3. No adjustments or oiling—low maintenance.
4. Dampens vibration—absorbs shocks.
5. Corrects misalignment automatically.
6. Smooth starting—no jerks.
7. Runs cooler—uniform pressure.
8. Controls torque by air pressure.
9. Greater capacity—more compact.
10. Remote control by air valve.
11. Replaces couplings.
12. Acts as clutch, slip-clutch or brake.

FAWICK *Airflex* CLUTCH

POWER CONTROLLED BY AIR

PREFAB WITH STEEL

—postwar wonder worker!



SHIPYARDS have speeded up fabrication and construction since United States Steel applied prefab to shipbuilding twenty-five years ago. Today, a destroyer can be built in one-third the time it took in 1918. Prefab designs call for materials that can be shaped and assembled quickly, handled and shipped conveniently, protected against deterioration. Steel, with its high strength-weight ratio, plus its ability to be cut, formed, welded, riveted, soldered, machined, stamped and finished, usually is the best material for these jobs.

The unmatched fabricability of steel is now helping tank plants, shipyards and aircraft factories to produce fighting equipment. Tomorrow, steel, "the universal material", will help industrial designers apply the advantages of prefabrication to many peacetime products—architectural units such as windows, cabinets, stairways, closets, and even complete bathrooms and kitchens. Prefab railroad cars, both freight and passenger, will relieve rail systems equipment shortages.

Let our engineers help you utilize U·S·S Steels to make your future products outstanding in appearance and performance, to enhance their marketability.

What will your "Designs for Tomorrow" need to make them successful?

ABSOLUTE SANITATION... *like this?*
Military hospitals use equipment made of porcelain enamel on U·S·S VITRENAMEL Sheets—where utter cleanliness is essential. The ductile steel base forms and fabricates easily, and the hard, bright, inorganic enamel gives lasting protection against stains and corrosion. Here's the material for your home appliances and plant equipment.

HIGH ENDURANCE . . . *like this?*
U·S·S COR-TEN High Tensile Steel truck frames insure downright dependability. COR-TEN has a yield point 1½ times that of structural steel; more than 3 times the stress resistance of non-ferrous "light" metal; plus extreme atmospheric corrosion resistance. Would these qualities help *your* equipment meet the challenge of a post-war world?

U·S·S STEELS FOR DESIGN

- U·S·S HIGH TENSILE STEELS *to resist corrosion and increase strength without adding weight.*
- U·S·S COPPER STEELS *to give twice the atmospheric corrosion resistance of regular steel at little additional cost.*
- U·S·S HOT-ROLLED AND COLD-ROLLED STEELS *to provide the basic advantages of steel, plus maximum economy in accordance with the needs of each job.*
- U·S·S ABRASION-RESISTING STEEL *to combat wear and friction.*
- U·S·S STAINLESS AND HEAT-RESISTING STEELS *to assure high resistance to corrosion and heat, and to reduce weight.*
- U·S·S CARILLOY ALLOY STEELS—*Special Steels for the special jobs of industry.*
- U·S·S PAINTBOND—*A galvanized, Bonderized sheet that permits immediate painting and holds paint tighter.*
- U·S·S VITRENAMEL—*Sheets designed especially for porcelain enameling.*
- U·S·S ELECTRICAL SHEETS *for motors, generators and transformers.*

"ONE AIM . . . VICTORY . . . BUY BONDS!"

USS

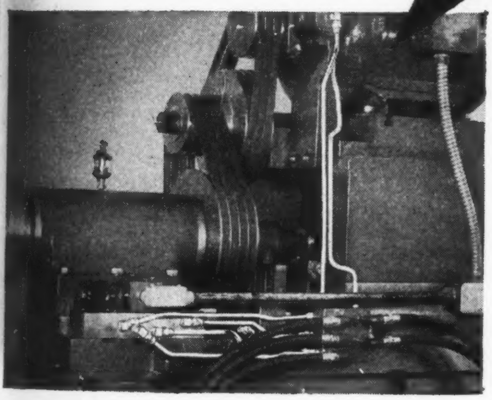
ONLY STEEL CAN DO SO MANY JOBS SO WELL

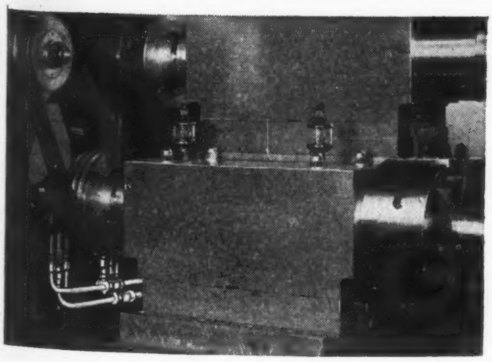
CARNEGIE-ILLINOIS STEEL CORPORATION

Pittsburgh and Chicago

Columbia Steel Company, San Francisco, *Pacific Coast Distributors*
United States Steel Supply Company, Chicago, *Warehouse Distributors*
United States Steel Export Company, New York

UNITED STATES STEEL





—for the Production Front

Many machine tools today are equipped with hydraulic controls and hydraulic feeds. Hydraulic oil pressure drives their tables as positively as it swings battleship turrets, as precisely as it adjusts laboratory apparatus.

Seamless steel tubing provides the necessary pressure lines for an ever increasing number of these machine tools.

From Michigan Seamless Tube Company, manufacturers of machine tools can obtain recommendations based on long experience in making pressure tubing, both for peacetime needs and for the war effort.

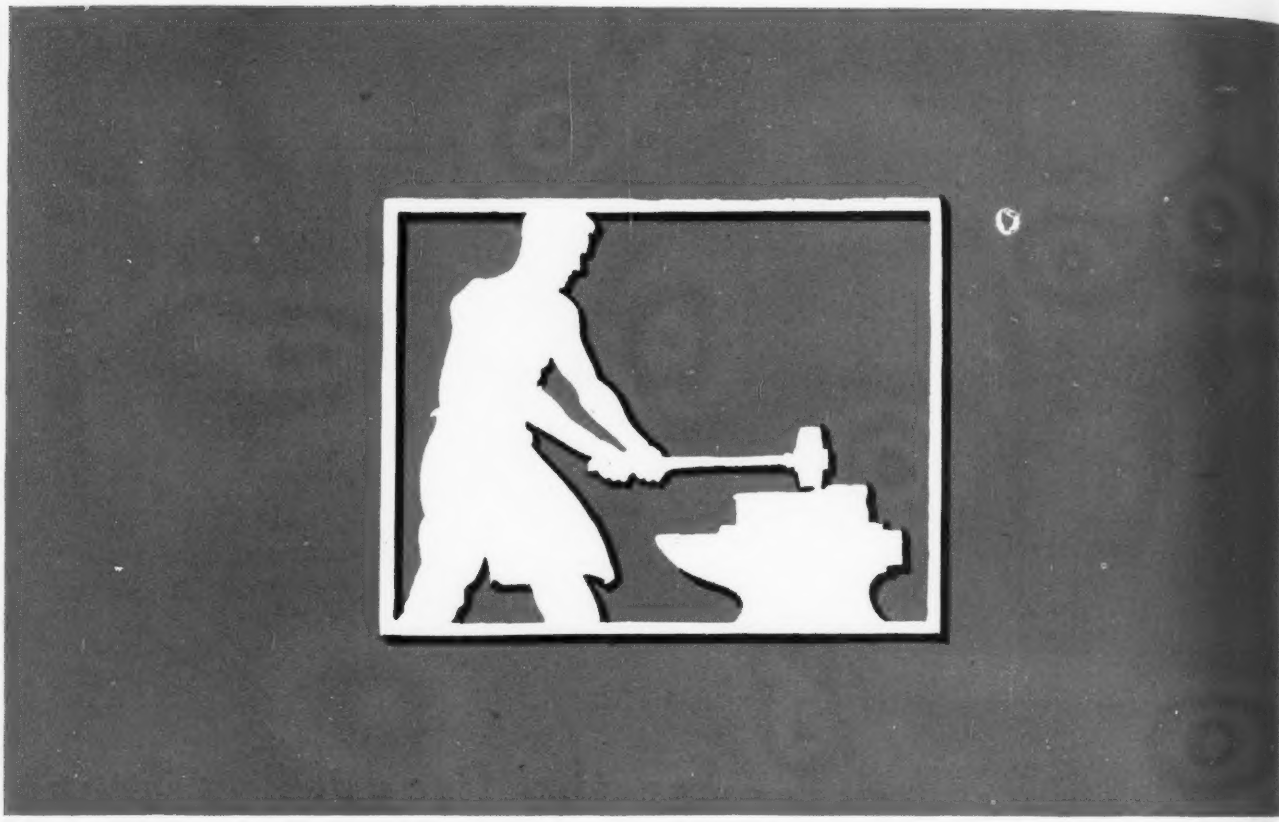
WHAT DO YOU WANT TO KNOW ABOUT TUBING?

In addition to original development work on pressure tubing, the Laboratory of the Michigan Seamless Tube Company is constantly engaged in studies of specific tubing problems. Ask for suggestions. If necessary, the Laboratory will conduct special studies to supply the information you need.

BACK THE ATTACK ★ ★ BUY WAR BONDS

ARMY E ★ NAVY
Awarded Feb. 12, 1943
First Star Sept. 9, 1943

MICHIGAN SEAMLESS TUBE COMPANY
SOUTH LYON • MICHIGAN



Follansbee for Steel

Sterling for Silver

What "Sterling" means to silver, the "Follansbee Smith" means to open hearth steel.

Ever since Madison was President, the Follansbee Steel Corporation and its predecessors have continuously enjoyed a reputation for quality. First it was as an importer of bar iron and tin plate, later as a steel producer. Products have changed. Methods have changed. But the policy of making products of the highest possible standard has remained constant.

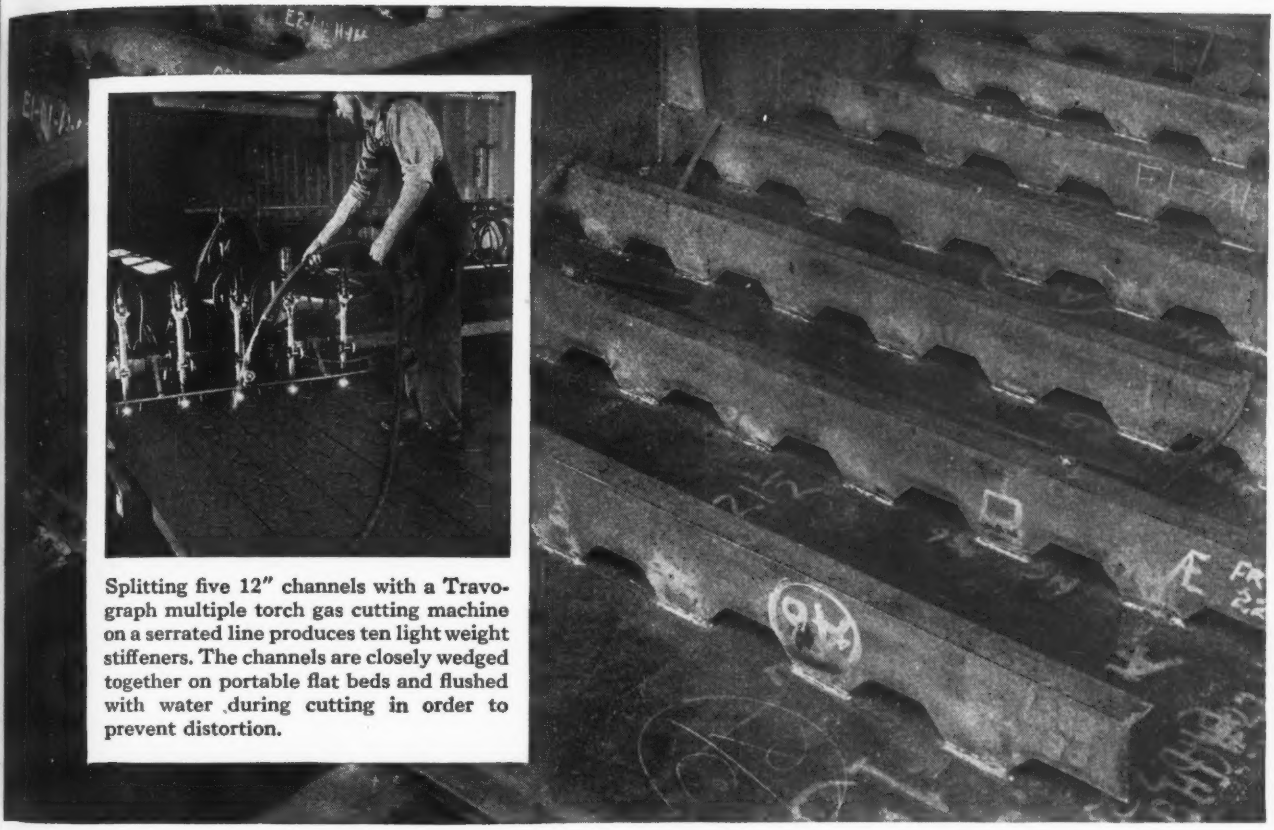
Today, Follansbee's compact, highly skilled organization is continuing that reputation by its ability to produce quality steel to meet the specialized requirements of its customers. Look for "Sterling" on silver . . . look for the "Follansbee Smith" on steel.

FOLLANSBEE STEEL CORPORATION

GENERAL OFFICES · PITTSBURGH 30, PA.

Sales Offices—New York, Rochester, Cleveland, Detroit, Milwaukee. *Sales Agents*—Chicago, St. Louis, Nashville, Los Angeles, Toronto and Montreal, Canada. *Plants*—Follansbee, W. Va. and Toronto, Ohio

ALLOY BLOOMS, BILLETS, BARS, SHEETS & STRIP
COLD ROLLED SHEETS & STRIP · POLISHED BLUE SHEETS · ELECTRICAL SHEETS & STRIP · SEAMLESS TERNE ROLL ROOFING



Splitting five 12" channels with a Travograph multiple torch gas cutting machine on a serrated line produces ten light weight stiffeners. The channels are closely wedged together on portable flat beds and flushed with water during cutting in order to prevent distortion.

SERRATED MEMBERS

Save Weight and Materials

Important savings in weight and materials are made possible by using serrated stiffeners or beams for large or small machines and structures. This type of member is quickly produced from standard plate or structural shapes by machine gas cutting.

Savings in cost and materials can be made by the use of such serrated beams, in most cases without the loss of structural strength or stiffness. This is a fact that is amply demonstrated by their use in ship and building construction. The same type of member can be profitably designed for a wide variety of war and post-war products and machines.

This is only one illustration of the broad design possibilities made possible by metal shaping with the oxyacetylene flame. An almost unlimited variety of metal shapes, many of which could not be produced economically by regular methods, may be accurately and quickly shaped by means of multiple torch flame cutting.

Air Reduction's nation-wide field engineering service and its research facilities are at your disposal to supply "know how" information on any design problem involving the use of the oxyacetylene flame and the electric arc.

★ BUY UNITED STATES WAR BONDS ★

AIRCO

WILSON

AIR REDUCTION

General Offices: 60 EAST 42nd STREET, NEW YORK 17, N. Y.

In Texas: MAGNOLIA AIRCO GAS PRODUCTS CO. • General Offices: HOUSTON, TEXAS

IT KEEPS MOTORS ROLLING MERRILY ALONG

Take a motor that has a built-in Klixon Protector and it just keeps "rolling merrily along" working on the job. For if the motor is overloaded and becomes dangerously hot, the Klixon Protector steps in and cuts off the power . . . waits for the motor to cool . . . then lets it start again either automatically or by manual reset—yet always allowing the motor to operate at peak capacity.

If you're having trouble with motor burnouts, or want protection against costly motor repairs and replacements caused by overloads, ask your supplier for motors with built-in Klixon Protectors . . . AC all sizes; DC up to 30 volts.

ARMY E NAVY

KLIXON

SPENCER THERMOSTAT CO., ATTLEBORO, MASSACHUSETTS

POOR COMMUNICATIONS COST 2000 LIVES

What about Ours Today?

THE unnecessary war of 1812 was declared two days after Lord Castlereagh announced in England that the "Orders in Council" (which caused the quarrel) would be repealed — but the Congress of 1812 didn't get the news in time.

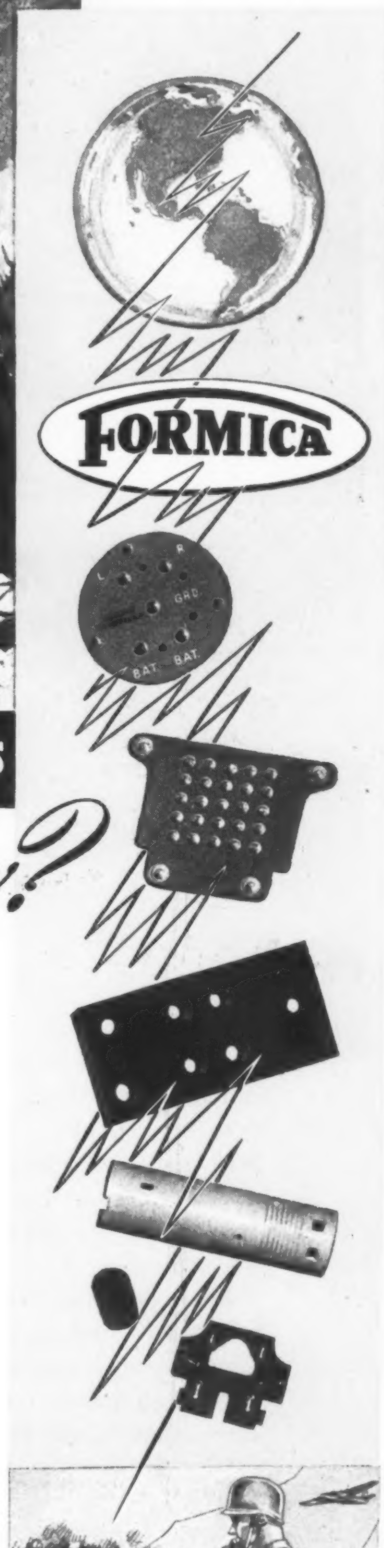
The final battle of New Orleans, costing 2,000 lives, was fought fifteen days after peace was signed at Ghent — but the armies hadn't heard the news.

Today news, propaganda, and battle orders can girdle the globe in a second if communications equipment is functioning perfectly.

Radio parts made of Formica help civil and military communications function perfectly because of Formica's excellent insulating qualities at radio and audio frequencies. In addition, Formica is light, strong, tough, moisture resistant, and readily machined. A material possessing such properties will have many new uses in the close knit world of tomorrow, some uses in your product no doubt.

ARMY E NAVY

THE FORMICA INSULATION COMPANY
4648 Spring Grove Avenue, Cincinnati, Ohio



Magnesium machines at *very high* speeds, taking a fine finish which makes extreme accuracy possible. Machine work can be held to close tolerances, therefore, even while boosting the speed of production. Think what this means to producers of vital war materials!

American Magnesium products, supplied to these manufacturers, add another plus which also helps speed this production. Their high quality—soundness and uniformity—causes Mazlo Magnesium Products, like the airplane wheels pictured above, to go through manufacturing lines a'sailing. High production schedules are easier to maintain.

Peacetime users of magnesium will profit similarly by depending upon American Magnesium as their source of supply. Our engineers, with more than twenty years experience in working with magnesium, can render valuable assistance in the design and fabrication of magnesium parts. For such help, write American Magnesium Corporation, 1703 Gulf Building, Pittsburgh, Pennsylvania.

Send for the new book, "Designing with Magnesium."

MAGNESIUM MAZLO PRODUCTS

REG. U.S. PAT. OFF.

AMERICAN MAGNESIUM CORPORATION

SUBSIDIARY OF ALUMINUM COMPANY OF AMERICA


You
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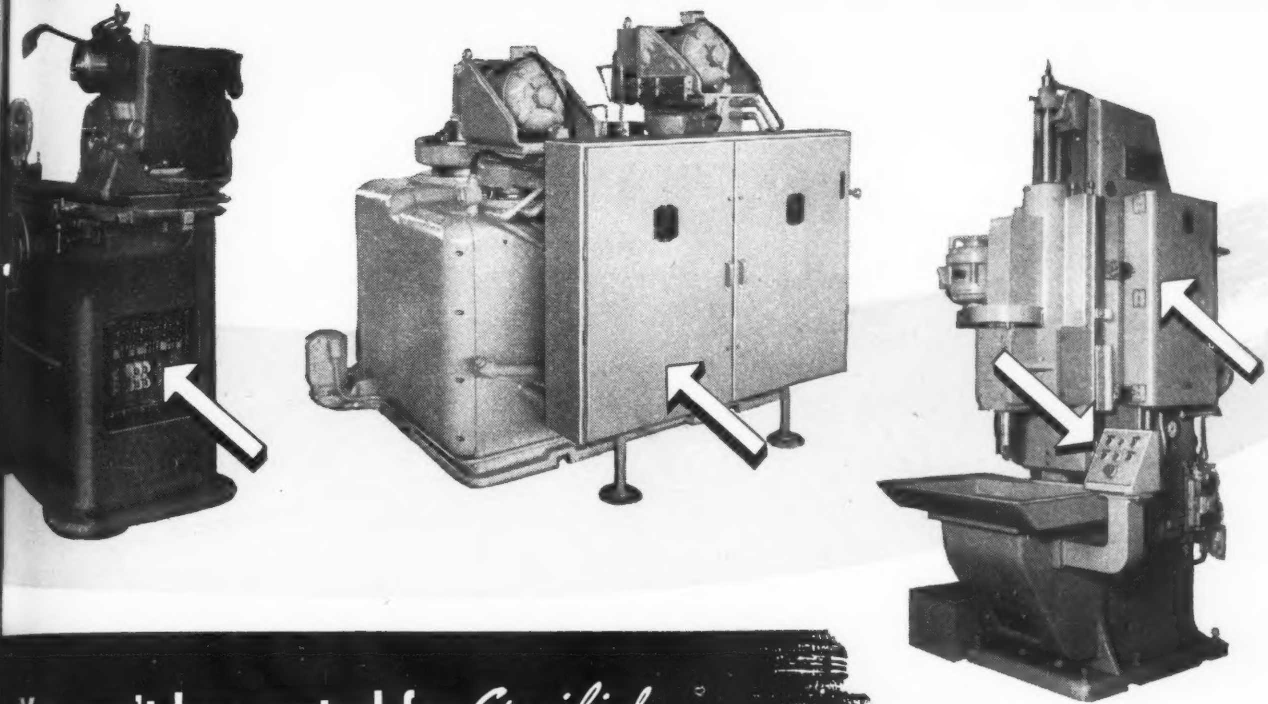
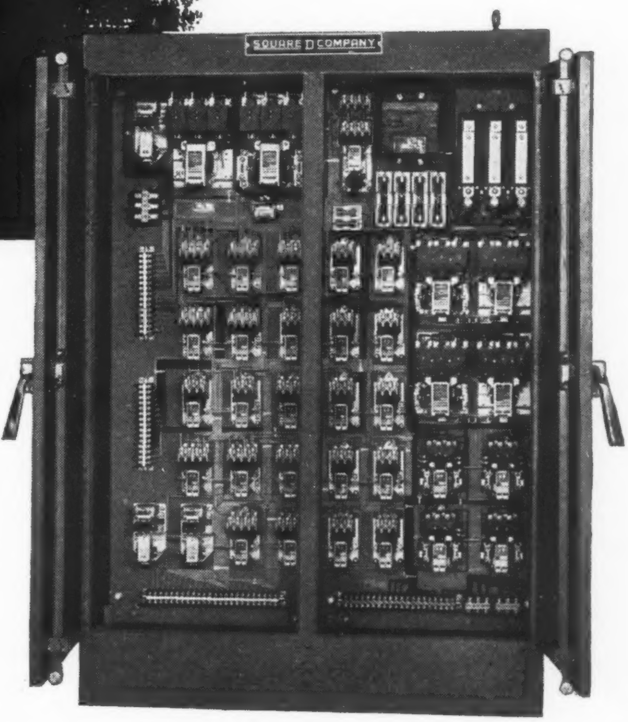


You can't buy control for *Specialized* machines from a catalog . . . but . . . Square D field engineers make it almost that easy . . .



Above — Electrical control for four-way horizontal drilling and tapping machine. Seven motors and seven solenoids power the specialized machine for which this control panel was designed and built.

Specialized machine tools with more efficient electrical control are pointing the way to increased war production in the face of manpower shortages.

One of the major assignments of Square D Field Engineers is working with machine tool manufacturers in designing the most practical, efficient control for such specialized equipment.

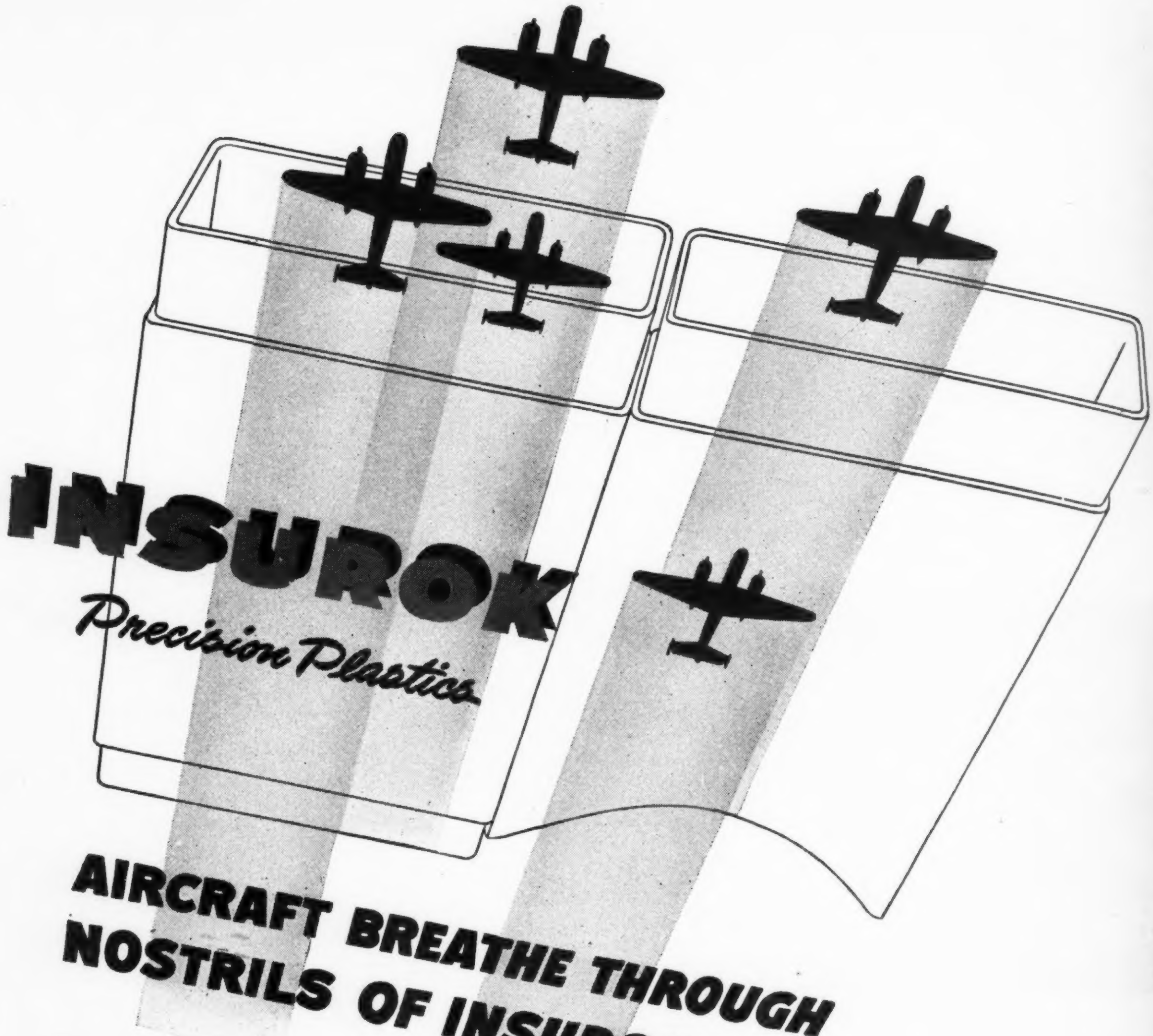
The unusual completeness of the Square D line enables our Field Engineers to meet almost any performance requirements. Standardized units, designed to perform many different functions, are all physically proportioned to make up compact, attractive control panels. There is no wasted space — yet there is complete accessibility for speedy inspection and maintenance.

Put your next electrical control problem into the hands of a Square D Field Engineer. See if that isn't the best way to get the results you need.

ELECTRICAL EQUIPMENT • KOLLSMAN AIRCRAFT INSTRUMENTS

SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES



AIRCRAFT BREATHE THROUGH NOSTRILS OF INSUROK

Every plane going into battle needs a ventilating system that will let fresh air in, but keep exhaust gases out. This calls for accurate air ducts—air ducts that won't leak. Performing this job on many of America's deadliest bombers and fighters are air ducts made of Laminated INSUROK . . . preformed and molded so that they not only possess great accuracy but high physical strength as well.

Laminated INSUROK, preformed and molded, is unusual in that it has the accuracy of a molded part, together with the strength of a laminated plastic. It is made from a specially prepared laminated tubing into an accurate *preform* and then *reformed* by further heating in a mold.

The result is a product of great strength and accuracy that may be the answer to one of your design problems. Why not call a Richardson Engineer and find out?

The RICHARDSON COMPANY

MELROSE PARK, ILL. NEW BRUNSWICK, N. J. FOUNDED 1858 INDIANAPOLIS 1, IND. LOCKLAND, CINCINNATI 15, OHIO
DETROIT OFFICE: 4-252 G. M. BUILDING, DETROIT 2, MICHIGAN NEW YORK OFFICE: 75 WEST STREET, NEW YORK 6, N. Y.

CASE STUDY—

Connecting metal tubing where there is major vibration . . . .

THE PROBLEM

An oil filter manufacturer required tubing connections for installation of filters. Due to flexible engine mountings these connections—extending between oil filter and crankcase — had to be able to stand up under major vibration. Rigid tubing lines connected with ordinary fittings frequently failed. Flexible lines had the disadvantages of shorter life and high cost because of the long lengths required. A satisfactory fitting for use with rigid (steel) tubing lines was sought.

THE SOLUTION

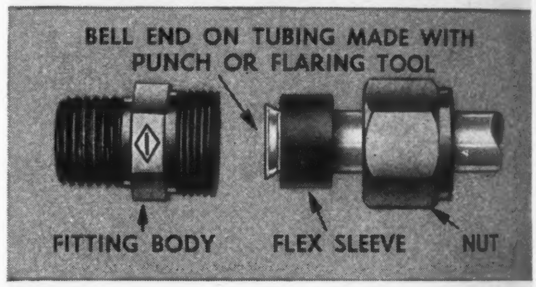
A newly developed, revolutionary Imperial fitting, the Flex Fitting—especially designed for use in joining parts which vibrate in different planes and amplitudes—was submitted to this filter manufacturer.

This fitting has a synthetic rubber sleeve incorporated which not only effects a seal but also provides a cushion which permits tubing to absorb vibration without damage to fitting or tubing itself.

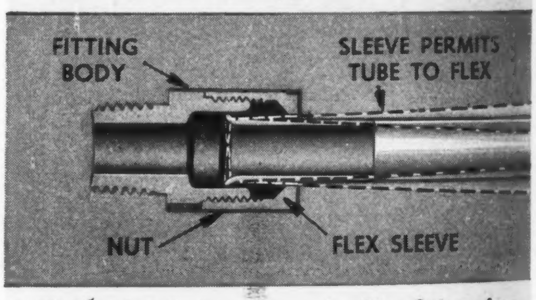
Exhaustive tests in the field by filter manufacturer proved the Flex Fitting was the practical answer to their needs. Advantages of the Flex Fitting in this instance were:

(1) Solved problem of tubing failure due to major vibration.
(2) Cut costs as compared to flexible lines.
(3) Provided greatly increased durability as compared to flexible lines.

In your product planning, whenever fittings for connecting tubing are involved, our broad experience in solving fitting problems can often be of assistance. There are over 2,000 sizes, types and styles of fittings—designed to meet virtually any need—in the complete Imperial line.



The view above shows a Flex fitting ready for assembly. The nut and the Flex sleeve have been slipped over the end of the tube and the tube has been belled with a flaring tool.



The sectional view shows the Flex fitting after assembly. Note that belled end of the tube does not contact the body. The Flex sleeve squeezes against the end of the fitting body and is compressed against the tube, making a joint that is pressure tight and yet the tube can be flexed through the angle shown.

THE IMPERIAL BRASS MANUFACTURING CO., 513 S. Racine Ave., Chicago 7, Ill.

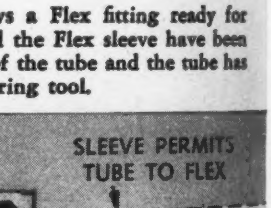
IMPERIAL

★ headquarters for tube fittings

COMPRESSION, S.A.E. FLARE, INVERTED FLARE, HI-DUTY, FLEX AND FN FITTINGS FOR COPPER, BRASS, STEEL, ALUMINUM AND FLEXIBLE TUBING • SHUT-OFF COCKS • NEEDLE VALVES • FUEL STRAINERS • TUBE WORKING TOOLS

BULLETIN NO. 3101 covers the latest practice in tubing connection work where minor vibration, major vibration or actual tube movement enter into the problem.

A copy will be mailed on your request



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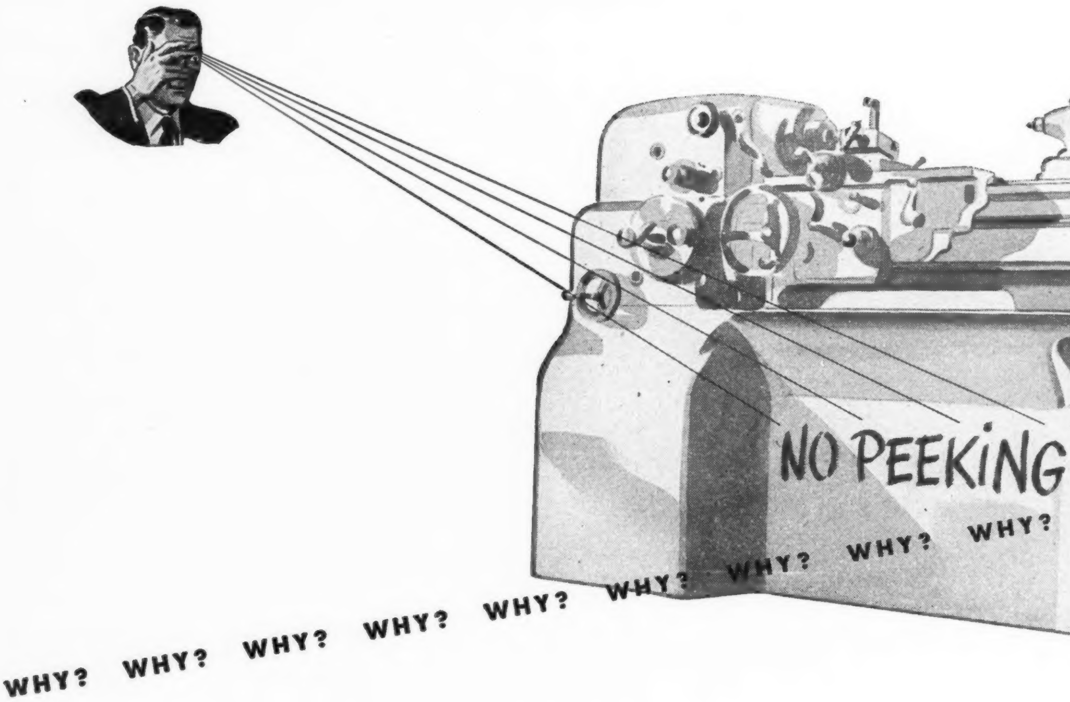


WHAT'S SO SECRET ABOUT A MACHINE TOOL, ANYWAY?

Must *Close It Up* also mean *Cover It Up?*

How much easier it would be to inspect and maintain a machine if you could *see through* to vital working parts.

That goes for hobbing, milling, broaching, automatic screw machines . . . for drills, grinders, turbines, looms, gear boxes . . . your own machines.

Why not open them up with glass? Keep an eye on their operation, on wear, on lubrication. Catch the little things before they become big headaches?

Glass is ready to take over such applications. Right now. As a plus to unequaled and lasting transparency, research has fitted glass with an iron constitution, and has added other amazing qualities which make it ready to do business for you in places you never thought of before.

When you design or redesign *anything* for industry, for the home, or for any structure, just remember that today there is a *transparent* material with unusual qualities of surface hardness, of strength, weathering, and permanence. This material combines a variety of chemical and physical properties found in no other substances. *It's glass.* L·O·F Glass to be precise.

Not the glass of your boyhood. Flat glass has come of age, too.

Won't you write us about any possible use of glass that may appeal to you, no matter how revolutionary or unusual? That's the way to really find out. Libbey·Owens·Ford Glass Company, 11123 Nicholas Building, Toledo, O.

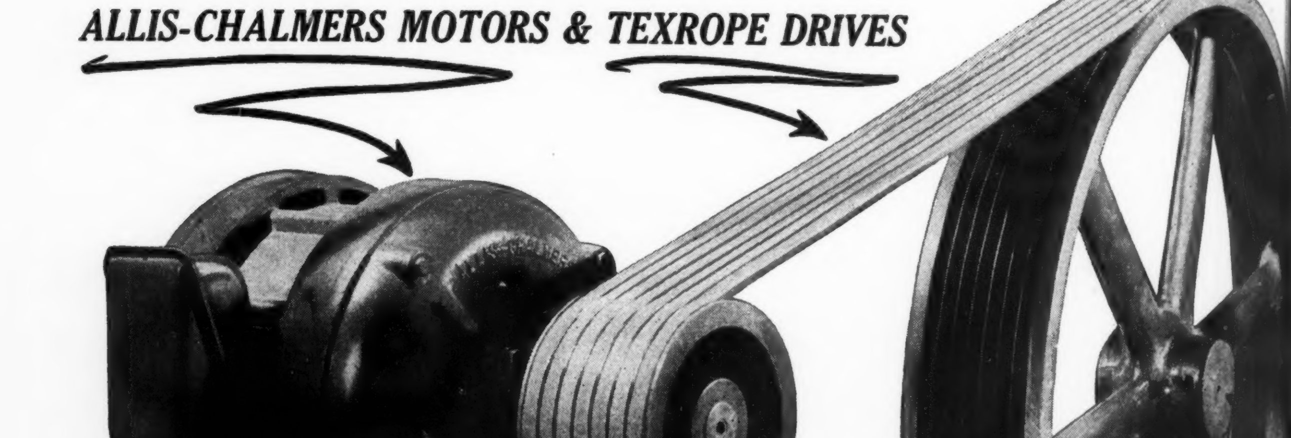
Destructible ?

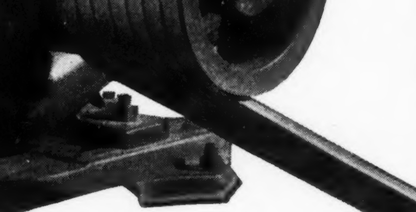
Wood-Metal-Plastics-Glass. No material is indestructible. However, barring unseen conditions, no material will fail on a job in which it has been properly specified and engineered. When our application engineers say "Yes", you can be sure about glass.

LIBBEY·OWENS·FORD

A GREAT NAME IN *Glass*

Here's the Team
New Power





1 In most applications, an 1800 rpm motor with Texrope Drive will ably do the job of a lower-speed, direct-connected motor —at lower cost in money *and materials!*

2 When you buy an 1800 rpm instead of 450 rpm 15 hp squirrel-cage motor, for example, 600 lb are saved. And *you* save well over $200 — with drive figured in!

3 Note that efficiency rises from 79% for the 450 rpm motor to 87.5% for the 1800 rpm motor. The 1800 rpm motor saves you over 30 kw/24 hr. day.

WE WORK FOR VICTORY WE PLAN FOR PEACE

ALLIS-

You can bank on

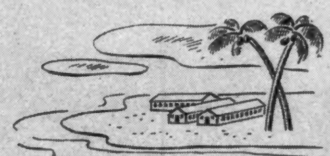
EGYPTIAN FINISHES

for

Steel Fabricated Buildings

for

Any Task-Force Structure



ANYWHERE

Picture of a hospital going somewhere. OFFICIAL U. S. NAVY PHOTO

OFFICIAL U. S. NAVY PHOTO

Above . . .
Here it is, set up and operating . . . where it's needed.

•

An entire hospital unit of steel fabricated buildings . . . overseas.

OFFICIAL U. S. NAVY PHOTO

Are you making steel fabricated task force building assemblies? If so, let us help you with your painting problems. We know your specification requirements.

Egyptian Finishes are giving complete satisfaction on hundreds of such buildings now in service on all the far flung fighting fronts of the world.

Egyptian Finish, for steel fabricated task force buildings, can be applied by dip, spray or roller coating method. It dries quickly for handling and packing with a minimum of special equipment.

This is but one of the many finishing problems with which we can help you. Today, Egyptian service to you is definitely two way: 1—it covers the war products you are now making; 2—it covers the peace products you'll be making in the post war period to come.

★ ★ ★

Special correspondence on finishing problems is invited.

THE EGYPTIAN LACQUER MANUFACTURING COMPANY

ROCKEFELLER CENTER, NEW YORK 20, N. Y

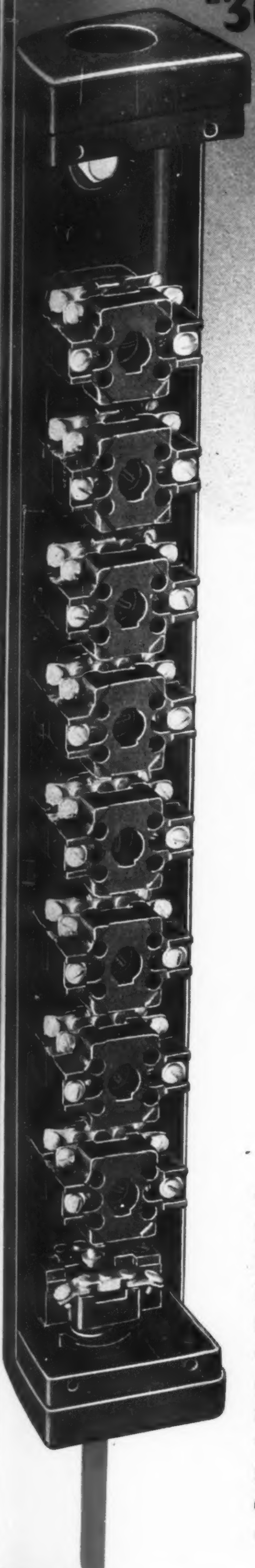
Egyptian's new U. S. Government "Spec" Book—4th Edition—is ready. It's helpful and it's FREE. Send for your copy. Please address Dept. D-12

EGYPTIAN FINISHES

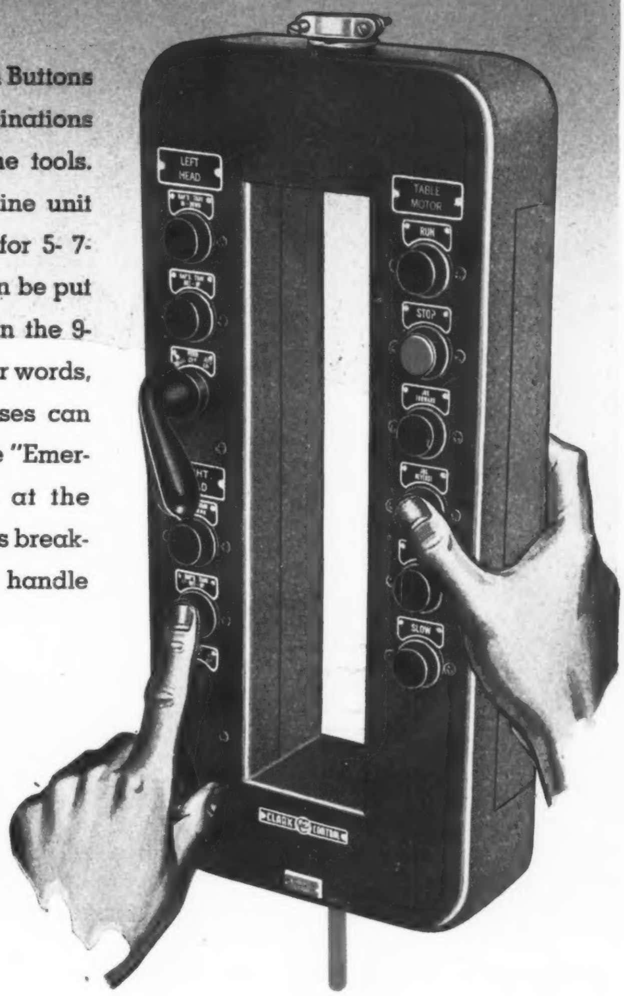
EGYPTIAN

SUPERIOR FINISHES

"3C" TYPE "D" HEAVY DUTY PUSH BUTTONS STATION FOR LARGE MACHINING OPERATIONS



"3C" Type "D" Heavy Duty Push Buttons are adaptable to countless combinations on frequently operated machine tools. To the left is a typical single line unit station. This type is available for 5- 7- 9- or 11-units, but 3 or 4 units can be put in the 5-unit, 6 in the 7-unit, 8 in the 9-unit, and 10 in the 11-unit. In other words, the same 5- 7- 9- or 11-unit cases can house 3 to 11 units, including the "Emergency-Stop" handle or stem at the bottom of the case, which permits breaking the circuit by moving this handle in any direction.



The Pendant Station to the right has been called the "Horse Collar" or "Doughnut" because of its resemblance; but it is a particularly efficient station for multiple operations. Its specially designed shape permits operation from any angle; it fits into spaces where a single line unit station would be awkward to use, and gives the operator instant control of all operations. This is available with up to 14 Push Button units, and a smaller number of units if Selector

OPERATED WITH EITHER HAND—FROM ANY ANGLE

Switches for jogging or inching are used. This form permits the use of either hand for actuating, the "Emergency-Stop" device at the bottom providing the same features as mentioned above.

In all "3C" Pendant Stations there is plenty of wiring space; all wiring parts are duplicates of other Type "D" Buttons, and wiring is simplified.

OFFICES IN PRINCIPAL CITIES

THE CLARK CONTROLLER CO.

1146 EAST 152ND ST. CLEVELAND, OHIO

Torque Talks

ON MOTORS FOR WAR AND POST-WAR NEEDS

5 GENERAL PURPOSE TYPES

THAT MEET **80%** OF SMALL MOTOR DRIVE REQUIREMENTS

Standard small motors can be designed to meet almost any combination of electrical and mechanical requirements for war and peacetime applications. And when products can be designed around a standard motor type, many advantages are gained . . . lower cost, quicker delivery, simplified maintenance.

For example, the five standard types shown here, when properly applied, will meet the majority of small motor drive requirements. Observe these five fundamentals in selecting them:

1. **What power supply must motor fit?** Voltage, frequency, phase (if a-c); and voltage (if d-c), are first considerations.
2. **What horsepower is required?** The motor must not only start and run the unit it is driving, but also handle any momentary overload. In case of doubt, application tests should be made. Duty cycle and frequency of starting may also affect size.
3. **What torque is required?** Motor torque characteristics must match those of load. Therefore, consider load requirements in terms of starting and breakdown torque. Curves, on the opposite page, show comparison between motor types.
4. **What are starting current limitations?** Many power companies restrict use of motors with high starting current. All motors shown here have locked rotor currents within NEMA standards for 115-volt motors, except the type FHT.
5. **Should burnout protection be applied?** (Single-Phase motors only.) When a motor is subject to overload or abnormal heat, built-in Thermoguard protection should be used.

Small motors have gone to war . . . some on wartime applications of peacetime products . . . many others on specialized war applications. For further information on Westinghouse small motors, watch for additional "Torque Talks." Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., Dept. 7-N. J-03194

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

SMALL MOTORS

Speaking of Electric Motors—

The day of trying to use a standard motor for a special job is about over.

Machinery designers, and production managers have learned that it is much more efficient and economical to obtain a motor with exactly the electrical and mechanical characteristics required to perform a specific job than it is to try to doctor up a standard "shelf" motor to do the job.

Speed and horsepower are no longer the major measuring stick of motor requirements — they are merely incidental to the many other characteristics available in electric motors today.

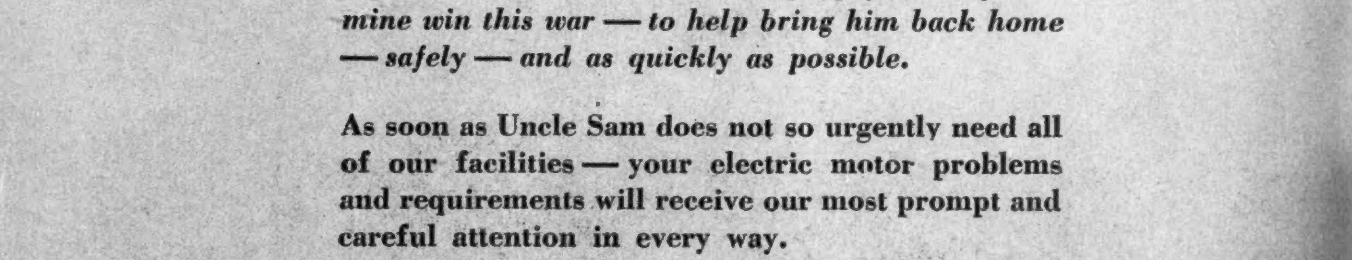
For over forty years we have been developing special motors for special jobs — our engineering department has a wealth of experience along this line —

Right now special Louis Allis motors are serving a major important role in helping your boy and mine win this war — to help bring him back home — safely — and as quickly as possible.

As soon as Uncle Sam does not so urgently need all of our facilities — your electric motor problems and requirements will receive our most prompt and careful attention in every way.

But right now — let's WIN this war!

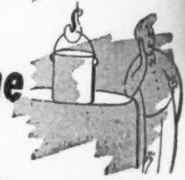
THE LOUIS ALLIS CO., MILWAUKEE 7, WIS.



SAVE

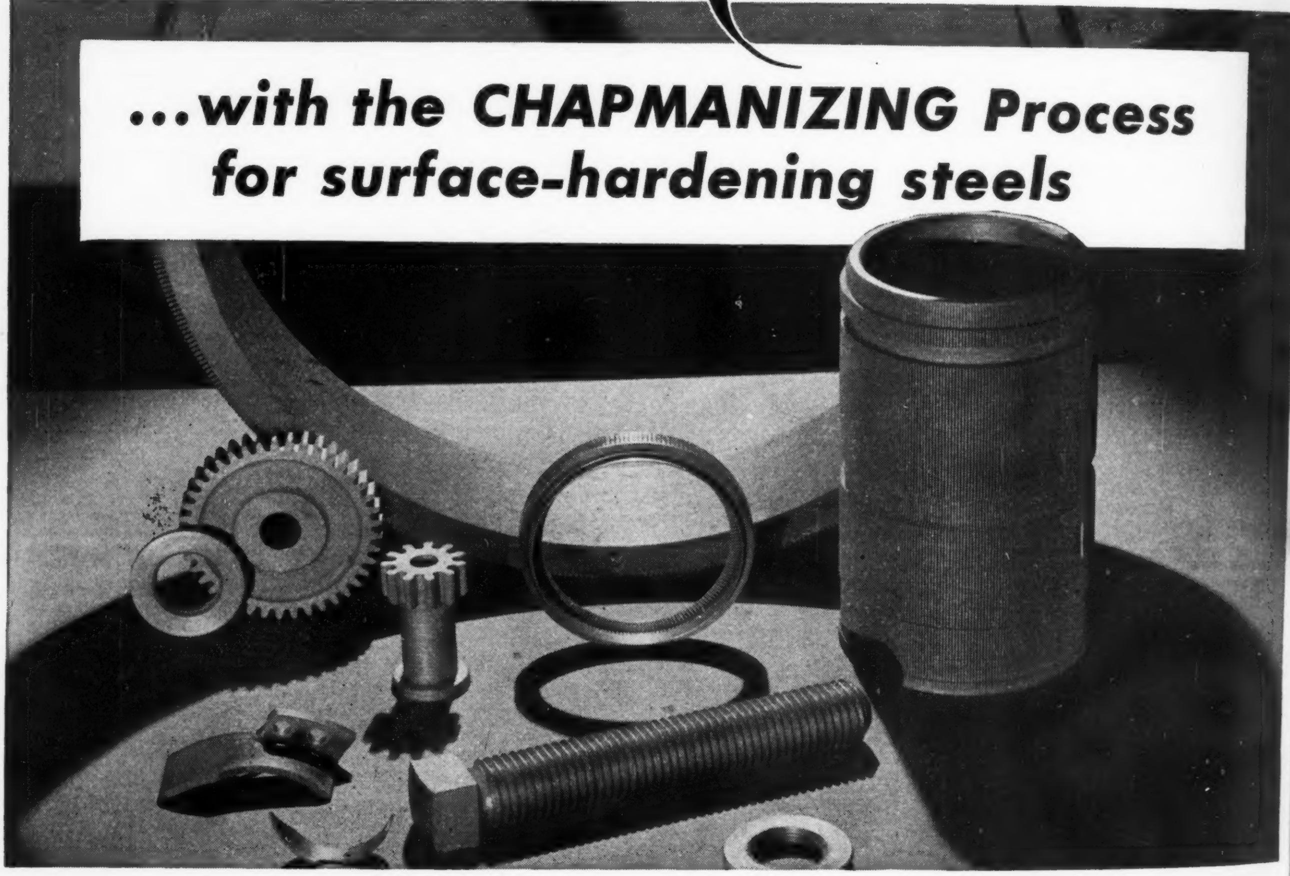
...waiting for scarce alloys

...hardening time



...finish-grinding time

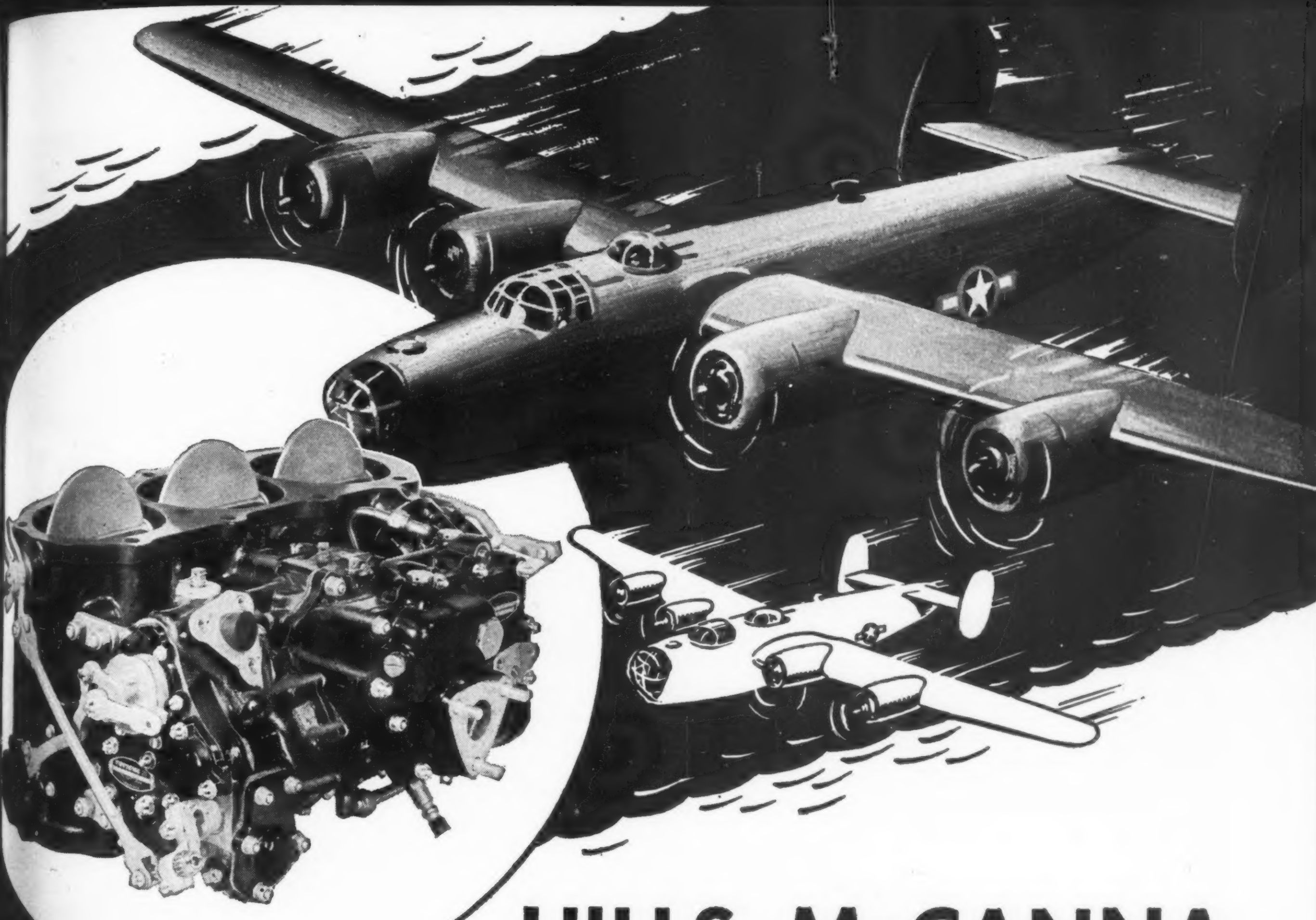
...with the CHAPMANIZING Process for surface-hardening steels

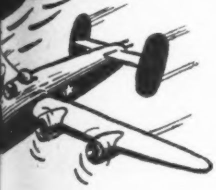


INSTEAD of waiting for delivery of critical alloys, you can get free-machining steels and have them Chapmanized to wear as well . . . if specifications permit you to substitute. And you can get this hardening done much faster than by any other process . . . for Chapmanizing takes only 1 to 4 hours to impart a tough-ductile case from .002" to .035". Finally, Chapmanized parts are so free from distortion that appreciably less finish-grinding is required.

Today, carloads of steel parts come every month into the Chapman plant, and into the plants of Chapman licensees from coast to coast, there to be promptly hardened and returned to war production plants which incorporate these parts into everything from tools to tanks. And in every field of use, in industry or on the battlefields, Chapmanized parts have proved their ability to stand up to the toughest and most continuous beatings. Find out *now* how you can use this high-speed, streamlined Contract Service on Chapmanizing to speed and improve *your* production of war materiel. Write to Dept. BL, Metallurgical Sales Division.

The Chapman Valve Manufacturing Co., Indian Orchard, Massachusetts





HILLS-McCANNA MAGNESIUM ALLOY SAND CASTINGS . . .

Give Important Aid to This Vital Member of the "Invisible Crew"–

THE BENDIX STROMBERG AIRCRAFT CARBURETOR

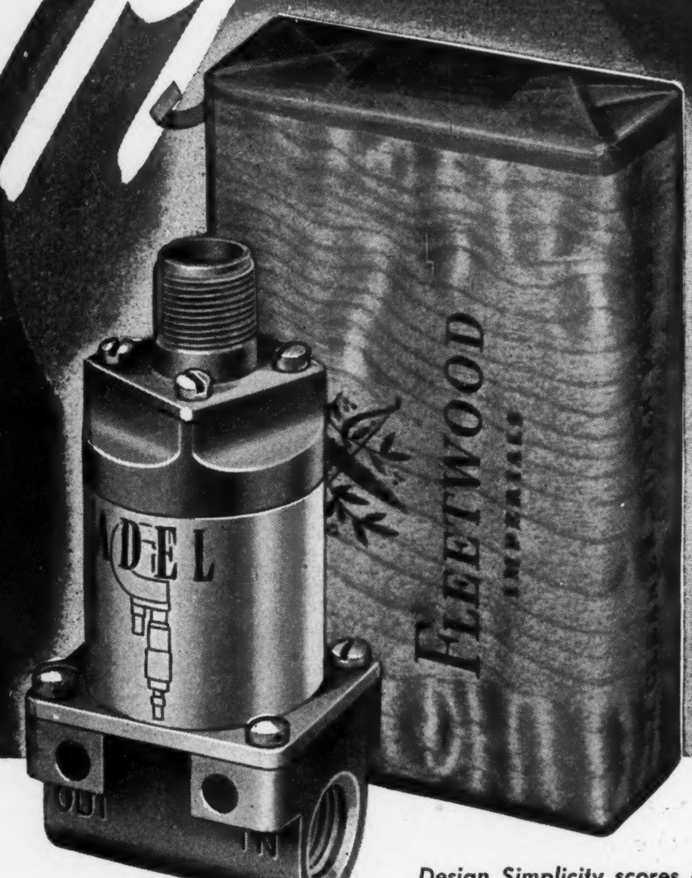
. . . by providing strong, light-weight Throttle Bodies to contribute their share toward the better fuel economy and more constant power which this superb Carburetor assures our fighting planes.

This assignment presented an out-of-the-ordinary casting problem, to provide correct physical properties and to assure pressure-tight castings. The unusual talent, experience and facilities of the Hills-McCanna organization met these conditions perfectly.

The important advantages of Hills-McCanna Magnesium Alloy S[illegible] Castings may similarly benefit your own civilian products in th[illegible] ahead. May we discuss the matter with you?

HILLS-McCANNA CO.

Approved...



SOCIETY OF AERONAUTICAL WEIGHT ENGINEERS INC.
WEIGHT
APPROVED

Seal of Approval Certificate No. 14 has been awarded ADEL'S new solenoid, 2-way shut-off valve by the Society of Aeronautical Weight Engineers, Inc.

Design Simplicity scores again in ADEL's new solenoid shut-off valve for remote control of anti-icing fluid flow to propellers, windshields, bombardier's windows, carburetors and pitot tubes. The new valve has a Dural body, is equipped with standard AN 3102-8S-1P receptacle and may be had in port sizes for ⅛" pipe thread or ¼" tube fittings. Valve is normally closed. Installations may be planned for any operating position. Current .25 amps 24 volts DC. Units are available for working pressures of 50 psi and 250 psi. In addition to anti-icing systems the valve may be used as heater fuel or oil dilution control, lavatory and drinking water control plus general industrial system installations. Write or call nearest engineering service office for complete information.

ADEL
PRECISION PRODUCTS CORP.
Burbank, California
Huntington, W. Va.

10777 Van Owen St., Burbank, Calif. • 1411 Fourth Ave., Seattle 1, Wash. • Admin. Bldg., Love Field, Dallas 9, Texas • 6560 Cass Ave., Detroit 2, Mich.
421 Mutual Home Bldg., Dayton, Ohio • 1444 Washington, Huntington, W. Va. • 303 Wareham Bldg., Hagerstown, Md. • 302 Bay St., Toronto, Ontario

Test machine cycles B. F. Goodrich hydraulic seals 40,000 times

A typical example of B. F. Goodrich improvement in rubber

In that machine B. F. Goodrich V-rings and O-rings, made from the B. F. Goodrich synthetic rubber called Ameripol, are tested for resistance to heat, wear and hydraulic oil. Held at 160 degrees Fahrenheit, the rings are subjected to 1500 lbs. pressure for as many as 40,000 cycles — that's 80,000 strokes — many times the normal service requirement.

At the other end of the scale is the cold room where Ameripol compounds are tested for resistance to a temperature of 65 degrees below zero; where it can be proved that the seals won't get brittle, won't wear unduly at low operating temperatures.

Extra fine tolerances provide another reason for the performance of B. F. Goodrich hydraulic seals. Years of experience in the manufacture of precision rubber goods made it possible for B. F. Goodrich engineers to mold rings to tolerances formerly obtainable only with machined steel.

And as an added safety and performance factor, every single V-ring and O-ring is given individual inspection by trained women operators, working under brilliant lights with powerful glasses. Rings that would appear perfect to most of us are discarded by these trained inspectors because of minute imperfections that might make the difference between a successful mission and a failure.

It all adds up to the kind of improvement that is constantly being made in B. F. Goodrich products; improvement that grows out of the thousands of hours of research, the years of experience that are a part of the B. F. Goodrich organization. Your B. F. Goodrich representative will be glad to discuss your sealing problems with you. Or write *The B. F. Goodrich Co., Industrial Products Division, Akron, Ohio.*

B.F. Goodrich

RUBBER *and* SYNTHETIC *products*


HOLO-KROME
fibro forged
SOCKET SCREW PRODUCTS
CAP SCREWS SET SCREWS PIPE PLUGS STRIPPER BOLTS KEYS
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It's New!
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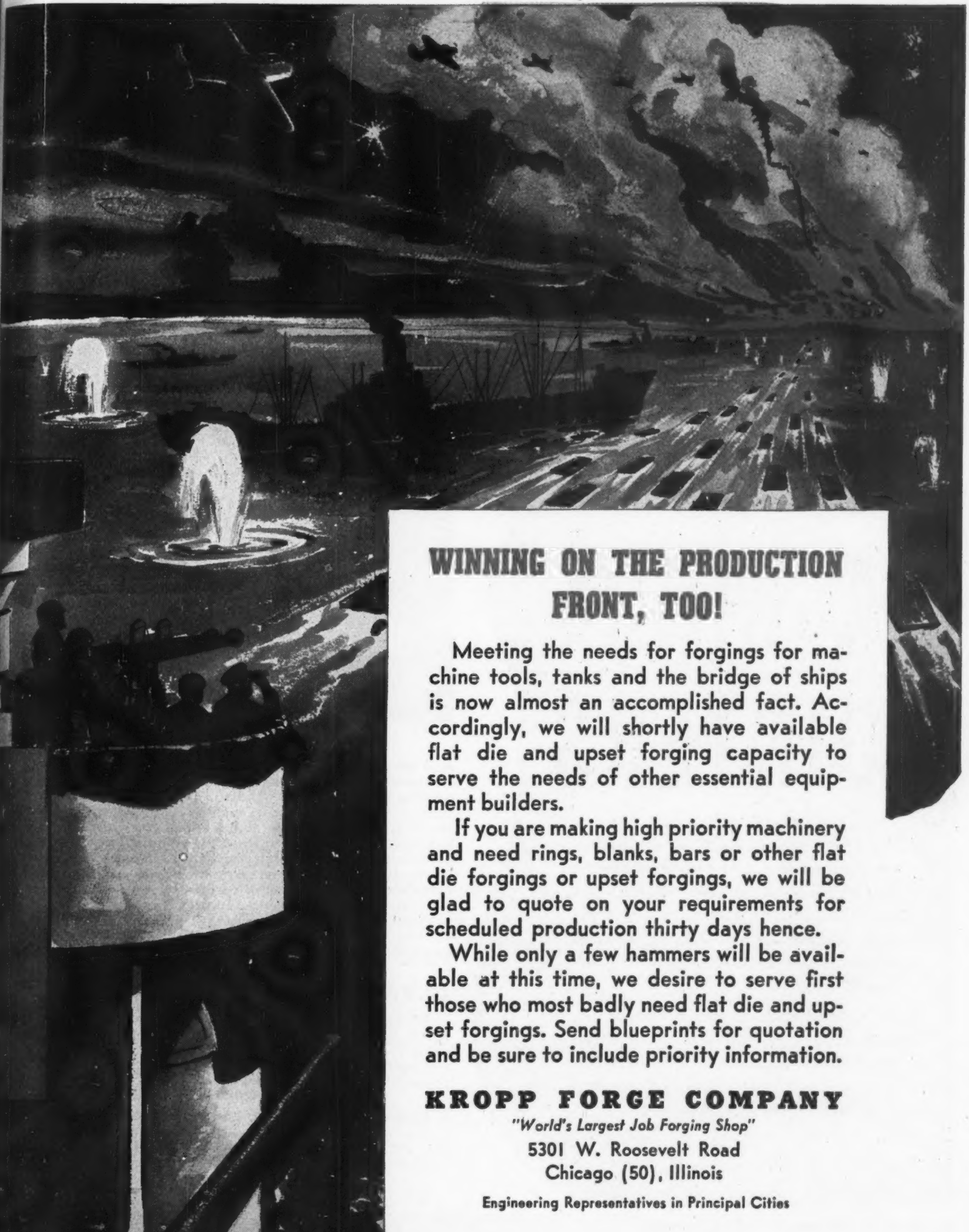
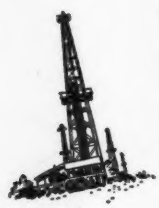
THE HOLO-KROME SCREW CORP. HARTFORD 10, CONN., U. S. A.



Cushioned power saves rigging and increases production 10% to 20%

In the Northwest woods where more than 300 Twin Disc Torque Converters (Lysholm-Smith type) are at work, loggers report the daily output of logs is increased 20% with the use of the Twin Disc Converters.

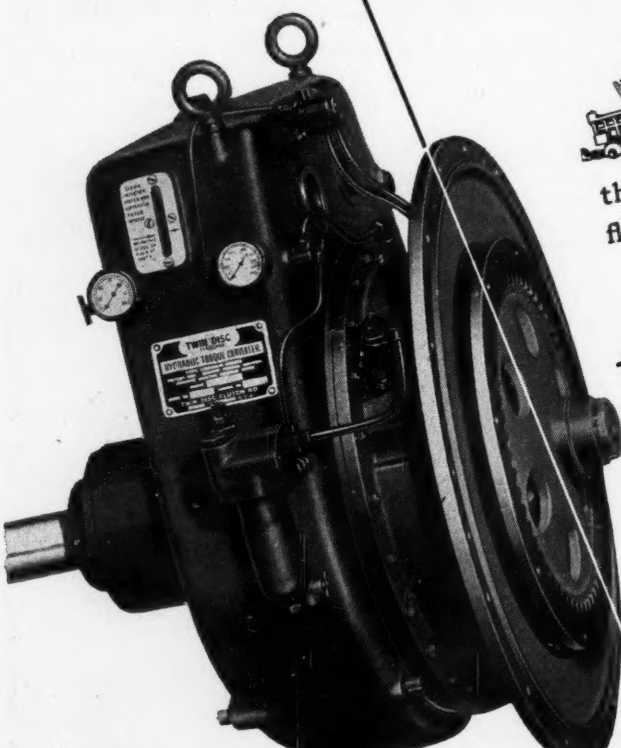


In the Oil Fields, drillers report a 10% increase in drilled feet with a lower operating cost. Ropes and cables last longer because the Converter cushions out all shock loads.

On Construction jobs, the Twin Disc Torque Converter gives cranes which are powered with internal combustion engines, all the desired characteristics of steam plus added flexibility and a more accurate control of the load.

On strategic war fronts . . . that part of the story must remain untold until the Allies have finished the job . . . but, here again, new performance records are being set up which will change all your pre-war ideas on transmissions for mobile equipment. Why not become thoroughly familiar with Twin Disc Hydraulic Drives? Operating records and descriptive literature are yours for the asking. Address, Hydraulic Division, Twin Disc Clutch Company, Rockford, Illinois.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin.



BOTTLENECKS

~~DAMN THE TORPEDOES~~

FULL SPEED AHEAD!

Making only Mounted Wheels and small Grinding Wheels—maintaining highest quality in spite of large quantities and rush orders—shipping them promptly. ***This is our job, our battlefield.***

With full WPB approval, we stopped making all large size grinding wheels and fixed our sights on wheels 3″ ***in diameter and under.***

We worked all around the clock, 24 hours a day, and in a short time were able to fill orders on time—And, our central location cuts time in transit. Today, there is no waiting. With the Army-Navy E at our masthead, we are going full speed ahead.

Half a century of specialization has established our reputation as the Small Wheel People of the Abrasive Industry. You can bank on us.

TEST WHEEL FREE—To get acquainted with Chicago Wheels, let us send one postpaid. Tell us size wheel and material you wish to grind.

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1101 W. Monroe St., Dept. MD, Chicago 7, Illinois

Send Catalog. Interested in: MD-12
☐Mounted Wheels ☐Grinding Wheels ☐Send Test Wheel. Size______

Name______

Address______

In numerous instances, MORGANITE carbon parts — because of their inherent self-lubricating properties and low frictional characteristics — have effected operating efficiencies and economies far beyond expectations.

For example, the trolley shoe illustrated above is typical. Heretofore of the metallic slide or pulley types, abrasion and wear on both collector and overhead wires, were severe. Pitting and arcing completed the deteriorating process, and replacements especially of "overhead" were not infrequent. MORGANITE carbon insert shoes were substituted, and wear became practically non-existent. The saving in critical materials was not only justified, but a decided advancement.

The MORGANITE designing and engineering department is available for customer-collaboration. Inquiries concerning present essential, or future peacetime needs can be addressed respectively to the Engineering Department or the Post-War Planning Committee — Morganite Brush Company, Inc., Long Island City, New York.

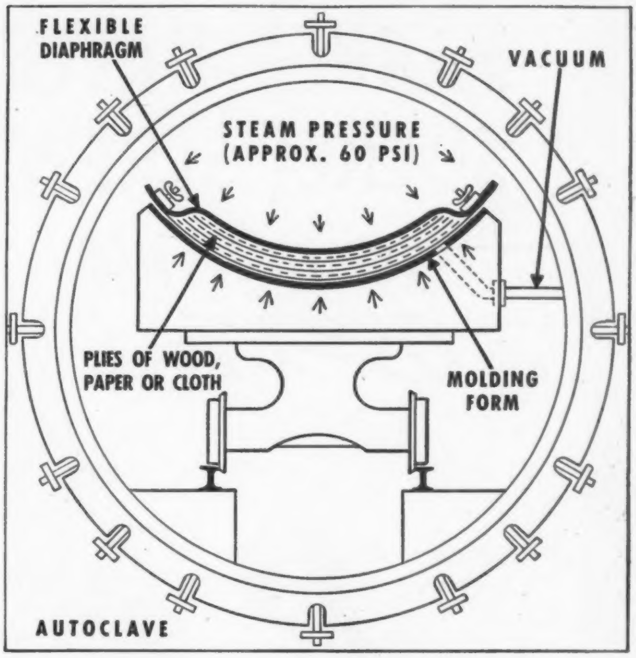
The MORGANITE Data Book on Carbon Brushes—describing the complete line of motor, generator and dynamotor brushes —will be sent free on request. Write for your copy today.

Molding Plastics: LOW PRESSURE LAMINATED MOLDING

From the engineering files of One Plastics Avenue

What Is Low Pressure Laminated Molding?

Low pressure laminated molding is a means of forming plies of resin-coated or resin-impregnated wood, paper, or cloth into a desired shape by the application of a uniform and relatively low pressure against a mold form. The pressure is usually applied through a flexible diaphragm with the application of heat to fuse and set the resin.



Laminating Materials

1. Wood veneer—For beauty, stiffness, strength and light weight.
2. Paper—For high tensile strength and low cost.
3. Cloth—For strength, toughness and special properties: chemical resistance, heat, and flame resistance, machineability, etc.
   a. Cotton fabrics
   b. Glass cloth
   c. Asbestos cloth

Advantages of Low Pressure Laminated Molding

1. Practically unlimited size of part in area.
2. Easy positioning of inserts or preformed shapes to provide assemblies and undercuts.
3. Low cost development and production molds and equipment.
4. Parts of thin section of unusual strength and lightness.
5. Ability to form undercut, hollow or complex parts.
6. Ability to form thick or thin sections, either uniform or non-uniform.
7. Use of materials which are strong, light weight, electrically insulating and corrosion resistant.
8. Wide choice of materials.

Disadvantages to Be Considered

1. Parts will have a smooth or mold finish on one surface only. The opposite side, formed by pressure applied through the flexible diaphragm, will be dense and filled, but not smooth or regular.
2. Shapes must be accurately preformed and built-up; the laminating material has little flow.

Items Adaptable to the Low Pressure Laminated Molding Process

Molded wing tips ★ Pilot seats ★ Ailerons ★ Tail cones ★ Data cases
Wing and fuselage sections ★ Air deflectors ★ Inspection covers ★ Radomes ★ Jettison gas tanks for aircraft
Funnels ★ Terminal boxes ★ Wing tabs ★ Photographic equipment ★ Fairings
Doors ★ Air ducts ★ Instrument cases ★ Fan blades ★ Small boats for the Navy

ONE PLASTICS AVENUE: This is the address of the home office for the General Electric Plastics Divisions. Here are located the research, development, design, and engineering departments of the nation's largest plastics molder. The combined experience of the craftsmen at this address assures every G-E Plastics customer results which meet designed specifications. The answer to your problem in regard to plastics is in our engineering files. For reprints of this advertisement, write section E-12, General Electric Co., Plastics Divisions, Pittsfield, Massachusetts.

Hear the General Electric radio programs: "The G-E All Girl Orchestra" Sunday 10 P.M.—E.W.T. NBC. "The World Today" news every weekday 6:45 P.M.—E.W.T. CBS.

"192,000 employees of the General Electric Company are on their jobs producing more goods and buying over a million dollars of War Bonds every week to hasten victory."

PD-32

PLASTICS DIVISIONS

GENERAL ELECTRIC

Compare the *Quality-Control* and you'll say PARKER-KALON SOCKET SCREWS *Every time*

THESE SCREWS LOOK EXACTLY ALIKE

Only Quality-Control can *foretell* the DIFFERENCE

When tested in the P-K laboratory, one may be O.K., the other may fail. P-K Quality-Control makes sure you get *only* screws that are O.K.

This 16-Point *"Quality-Control"* check up --unequaled in the industry-- protects P-K Socket Screw users

The specially equipped P-K Laboratory checks on 1—Chemical Analysis. 2—Tensile Strength. 3—Ductility. 4—Torsional Strength. 5—Ability to take Shock Loads under Tension. 6—Resistance to Shock Loads under Shear. 7—Hardness. 8—Head Diameter. 9—Head Height. 10—Concentricity of Head to Body. 11—Socket Shape. 12—Socket Size. 13—Socket Depth. 14—Centricality of Socket. 15—Class 3 Fit Threads. 16—Clean Starting Threads.

You get unusual protection against "doubtful" screws when you specify "Parker-Kalon" . . . and it costs no more. Parker-Kalon Corporation, 192-200 Varick St., New York 14, N. Y.

PARKER-KALON *Quality-Controlled* SOCKET SCREWS

NICKEL AIDS THE CONSTRUCTION INDUSTRY

to KEEP 'EM WORKING!

Engineers who design construction equipment can take pride in the construction industry's greatest achievement...its part in building America's "Arsenal of Democracy."

For they contributed to that amazing success, even long before the war started. They designed the tools with which the job was done...found ways to make equipment durable, and thus prevented many a breakdown of machinery at this critical time when nothing must interfere with the drive toward Victory.

Familiar to them, as a means of giving longer life to construction equipment, is the widespread use of Nickel Alloys. Those engineers have learned from long experience that Nickel imparts toughness, strength, and corrosion resistance to ferrous and non-ferrous metals, and thus assures improved performance under the most severe conditions.

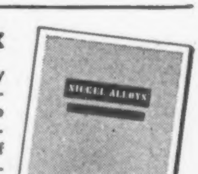
Among them, as with men in many other industries, the saying is that "a little Nickel goes a long way" toward increasing dependability of machine parts—from gears to scraper blades, from dipper teeth to crusher rolls.

The experience of contractors, engineers, and machine operators in the field supports this conviction of the designing engineers...proves that the products of leading manufacturers stand up longer under the stress of exacting service.

It has been the privilege of INCO engineers and metallurgists to cooperate with the construction industry for many years. To men in all industries who desire assistance in the selection, abrication, and heat treatment of ferrous and non-ferrous alloys, the International Nickel Company cordially extends an offer of counsel and data.

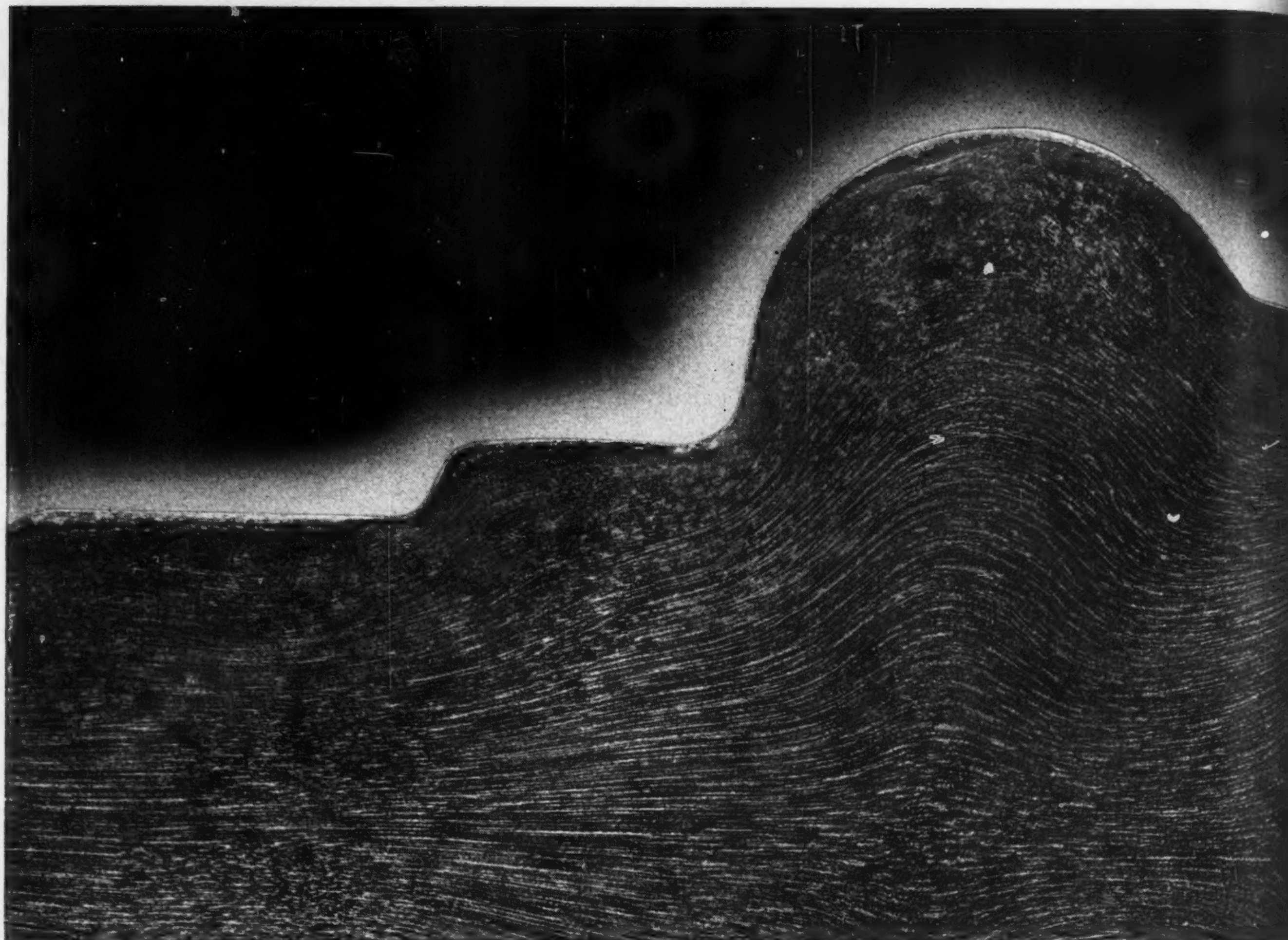
New Catalog Index

New Catalog C makes it easy for you to get Nickel literature. It gives you capsule synopses of booklets and bulletins on a wide variety of subjects—from industrial applications to metallurgical data and working instructions. Why not send for your copy of Catalog C today?



** Nickel **

THE INTERNATIONAL NICKEL COMPANY, INC., *67 Wall St., New York 5, N. Y.*



LINES OF *Most* RESISTANCE

This photomicrograph shows a cross-section of a drop forged machine part.

One good look at it will show you the reason for its extra strength and stamina. Note how the lines of flow follow the exact contour of the part—how the sinewy structure is securely knit together.

Here's maximum resistance in metal—the ability to withstand shocks and strains without flinching—and to do it day in and day out. It's the assurance of service, efficiency, and, in the long run, maximum economy.

This is a characteristic of all drop-forgings—and it's one of the reasons why Forgings by Phoenix are used in the manufacture of much of the equipment for our armed forces—equipment that must stand up under the most grueling punishment.

In planning your product for post-war markets you'll find it well worth while to consider the use of Forgings by Phoenix. Our engineers will gladly work with you—and there's no obligation.

Forgings by
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PHOENIX MANUFACTURING COMPANY
CATASAUQUA, PENNSYLVANIA

THE HANSEN MANUFACTURING CO.

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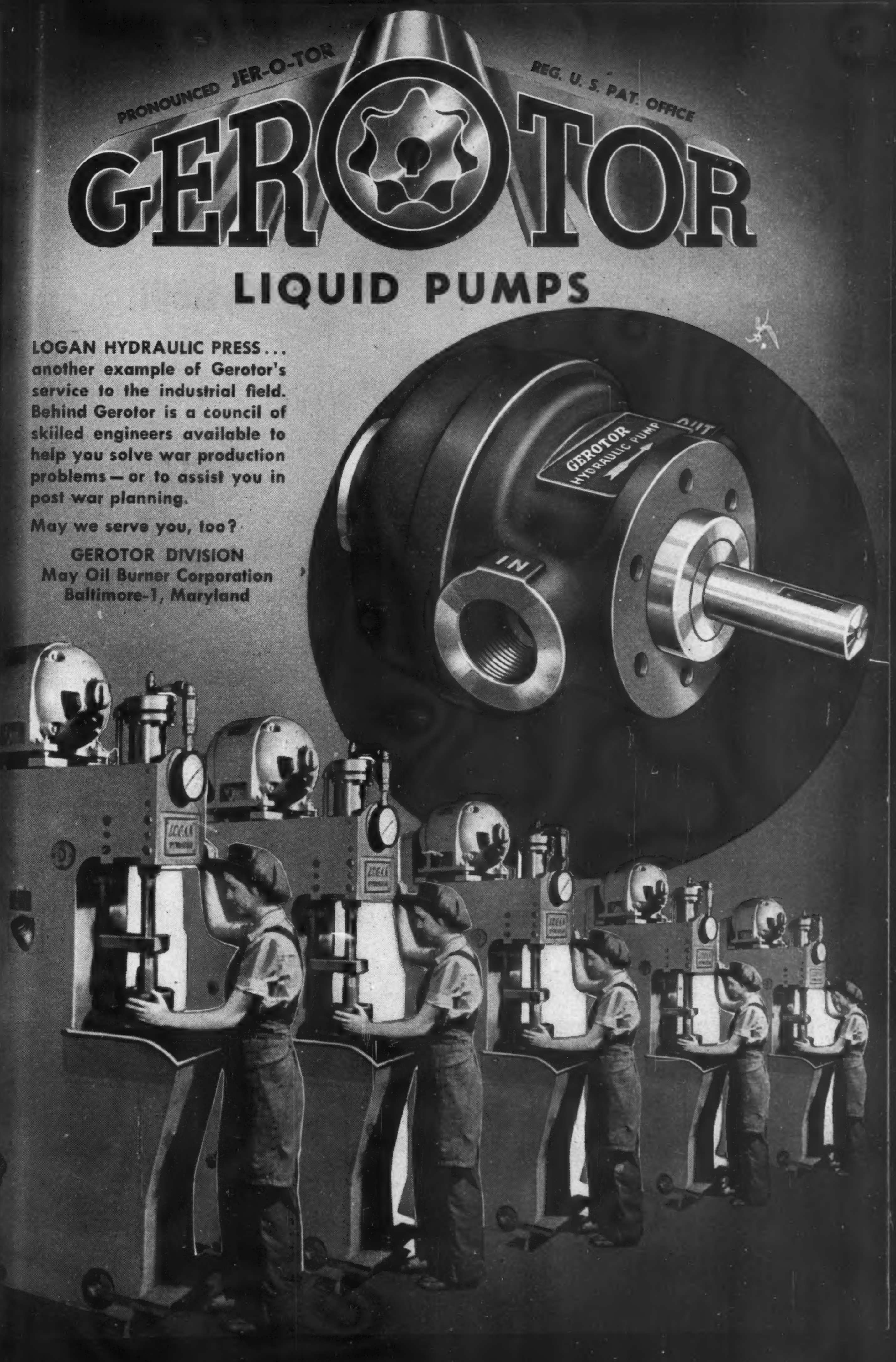

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There's Been a Big Change

A*lmost any old-timer* will give battle if you question the advantages of living in the old days. But few will deny that change in the *mechanical* world was inevitable, and good.

Take tapered roller bearings. Tyson found the way to add more rollers around the raceway—developed a heavy-duty bearing which solved many an industrial and transportation problem.

Actually, a Tyson "All-Rolls" Bearing has *thirty percent more rollers*, on the average, size for size. Obviously, this means greatly increased load capacity. Many users say bearing life is doubled. You can depend on it—Tyson is the most advanced, strongest, longest-lived bearing ever built.

* * *

The big name in bearings today is . . . TYSON!

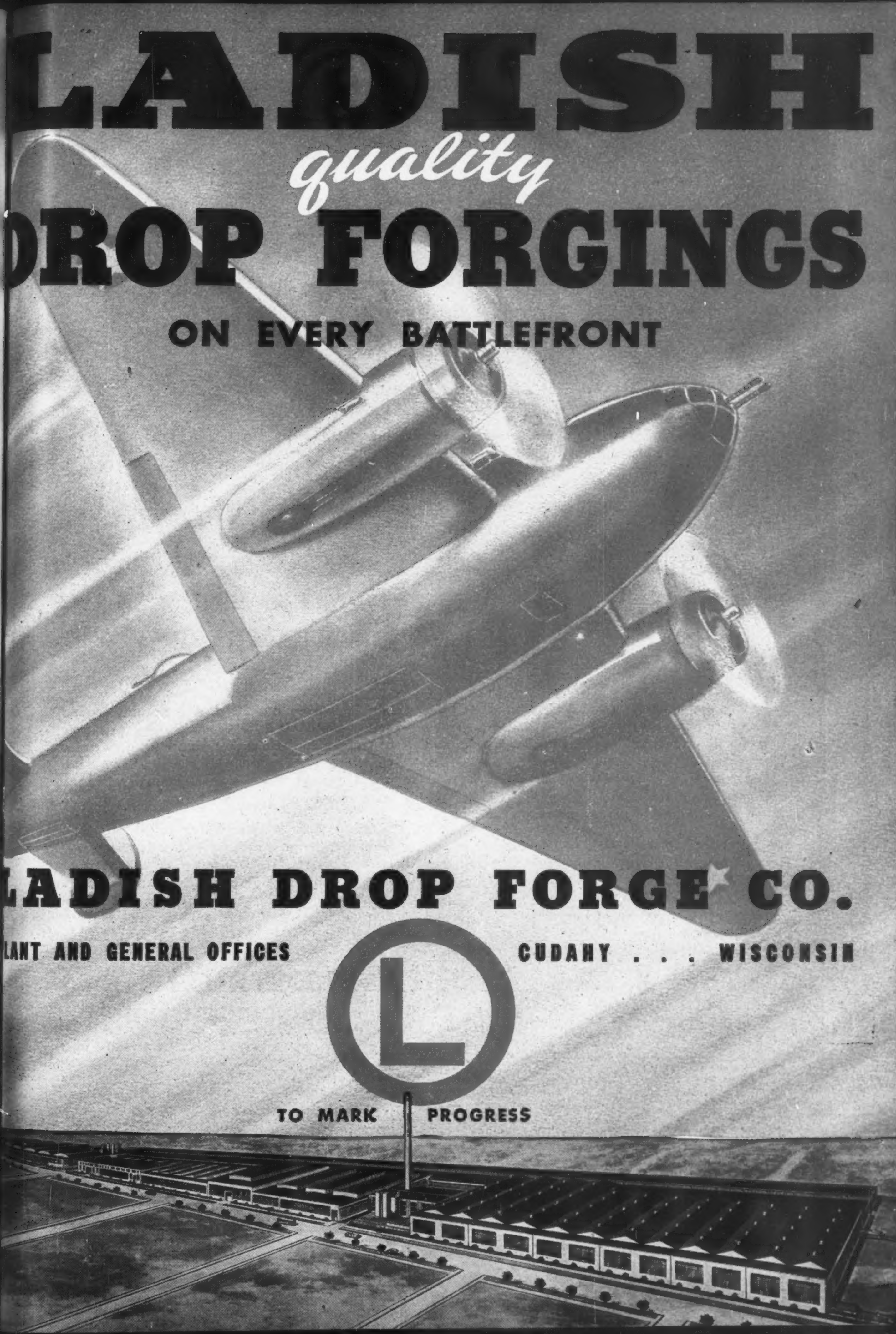
TYSON BEARING CORPORATION, MASSILLON, OHIO

COUNT THE ROLLS · THE ROLLS COUNT

Tyson

TODAY'S HEAVY-DUTY BEARING

★ BUY MORE WAR BONDS ★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ROP FORGINGS
ON EVERY BATTLEFRONT
ADISH DROP FORGE CO.
LANT AND GENERAL OFFICES
CUDAHY . . . WISCONSIN
TO MARK PROGRESS

Installing a 48" PD "C" section 8 groove QD Sheave on a 7" stroke horizontal air compressor. The QD Sheave weighs 440 pounds, about four times the girl's weight.

A NEW DESIGN

...SPEEDS ASSEMBLY, REDUCES BEARING STRESSES, STAYS TIGHT ON THE SHAFT AND FITS ALL APPLICATIONS

Military and industrial design engineers everywhere have acclaimed the New Worthington Q.D. (quick detachable) Sheave with its superior operating and maintenance advantages, as the guarantee against long delays and costly shut-downs when assembling or repairing Vital DriveR and DriveN machinery.

The Q.D. Sheave construction principle incorporates a split hub that is easily positioned on the shaft. The tapered rim is pulled up on the tapered hub with pullup bolts. When detaching the rim from the hub, the pullup bolts are used as jack screws and inserted into the tapped holes in the rim. This New Sheave Design is your assurance of a positive fit on the shaft, yet EASY TO GET ON AND EASY TO GET OFF... and that applies to those Giant Driven Sheaves often weighing thousands of pounds, as well as the smaller driver.

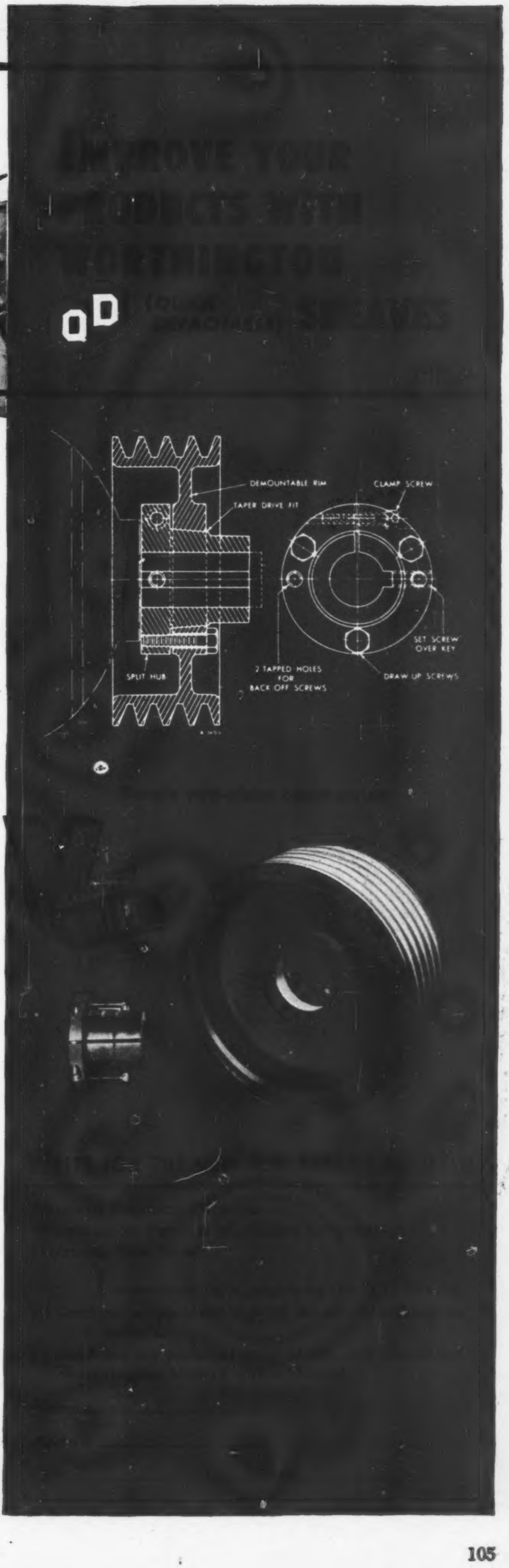
No engineering changes are necessary to design the Q D. Sheave into your products.

Investigate today. **Q. D. Sheave features are found in no other sheave on the market today and they cost you no more. Arrange for your demonstration of the Q. D. principle today. The Worthington district office engineer in your area will gladly call at your plant.**

WORTHINGTON
MULTI-V-DRIVES

COMPLETE DRIVES **SHEAVES OR BELTS ONLY**

WORTHINGTON PUMP & MACHINERY CORPORATION
GENERAL OFFICES: HARRISON, N. J.



FOR DEPENDABLE PRODUCTION
Turn To "EVEN TRIM"
Spiral Wound Brushes

Gain the benefits in uniform finish and uninterrupted production which these engineered-to-the-job brushes offer. There's a type for every finish desired, and for economy, they are refillable.

Let one of our engineering representatives work out the spiral wound brushes for your specific needs.

No obligation. Write or telephone today.

Brush Division PITTSBURGH PLATE GLASS COMPANY *Baltimore, Md.*

FOR DEPENDABLE SECURITY BUY U.S. WAR BONDS AND STAMPS

For the Factories of Today and the Industrial World of Tomorrow

● Somebody has to blaze the trail to new achievements—even when everybody is working to the breaking point on current production. "Siewek Engineering" offers a staff of trained creative men to press on into the future under your direction.

This is just the sort of service which management can scarcely expect of its own hard-pressed engineering force. In addition, the "outside viewpoint" on your problems offers special possibilities. Write, to say you would like some details of Siewek Engineering and its past accomplishments.

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SIEWEK ENGINEERING DIVISION

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CHICAGO 10: 506 N. Dearborn St. • DETROIT 26: 2011 Park Ave. • HARTFORD 3: 209 Pearl St.

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No "softies", these "Unbrako" Self-Locking Hollow Set Screws! Made tough at the start, they're hardened to "stand the gaff" and possess almost unbelievable strength, as proved by actual physical tests. What's more, they defy the menace of vibration and will not work loose of their own accord. When tightened as usual, the knurls *dig in and lock automatically.* Yet they can be readily removed with a wrench and used over and over again any number of times. Available in all sizes from No. 4 to $1\frac{1}{2}''$ diameter. Remember the name—be sure to specify "Unbrako" on your next order.

Knurling of Socket Screws originated with "Unbrako" years ago.

OVER 40 YEARS IN BUSINESS

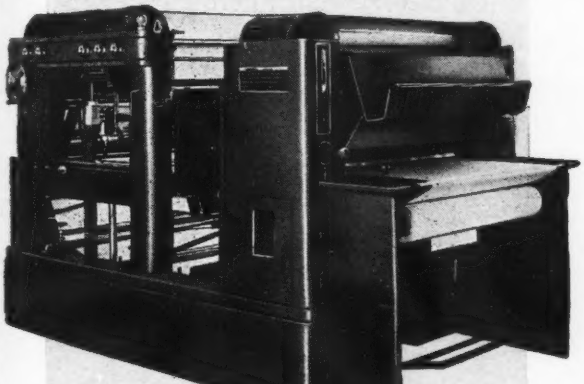
STANDARD PRESSED STEEL CO.

JENKINTOWN, PENNA., BOX 102 • BRANCHES: BOSTON • DETROIT • INDIANAPOLIS • CHICAGO • ST. LOUIS • SAN FRANCISCO

Quick Action

EXCLUSIVE PEASE FEATURES SPEED BLUEPRINT PRODUCTION

- ★ **Sliding "Vacuum-like" Contact** smooths out tracings, prevents errors in printing.
- ★ **Three Speed Lamp Control** provides operation at 10, 15, or 20 amperes, minimizes running speed and dryer heat changes.
- ★ **Actinic "No-Break" Arc Lamps** burn for 45 minutes without breaking arc, resume instantaneously.
- ★ **Horizontal "Floating" Water Wash** floats prints free from tension and prevents wrinkles, stains, bleeding.
- ★ **Quick Change Chemical Applicator System** very economically allows change from Blueprints to Negatives in 20 seconds.
- ★ **Eight-inch Drying Drums,** thermostatically controlled, heated by gas or electricity, dry the prints "flat as hung wallpaper."



PEASE "22-16"
Continuous Blueprinting, Washing, Developing and Drying Machine . . . Actual Production Speed 20 feet per minute. PEASE "22," not illustrated, has an actual production speed of 30 feet per minute.

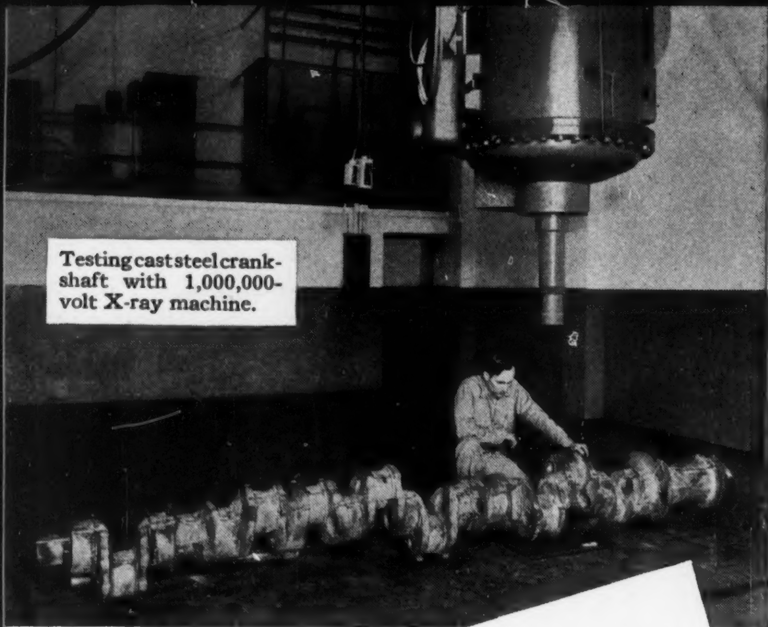
Co-ordinating the work of Engineering and Production Departments when rapid industrial changes are the order of the day is where Pease Continuous Blueprinting Machines shine.

Design changes necessitate **quick action** in furnishing Blueprints. Pease Continuous Blueprinting, Washing, Developing and Drying Machines make this **quick action** possible.

Engineering Departments from coast to coast are speeding changes with Pease Blueprinting Machine production speeds of 30 feet per minute on Model "22" (20 feet per minute on Model "22-16" illustrated). Pease machines deliver quality Blueprints at lower cost per square foot than any other tracing reproduction equipment.

THE C. F. PEASE COMPANY
2606 WEST IRVING PARK ROAD • CHICAGO 18

Pease Blueprinting Machines — A TYPE AND SIZE FOR EVERY REQUIREMENT INCLUDING DIRECT PROCESS PRINTING AND DEVELOPING MACHINES

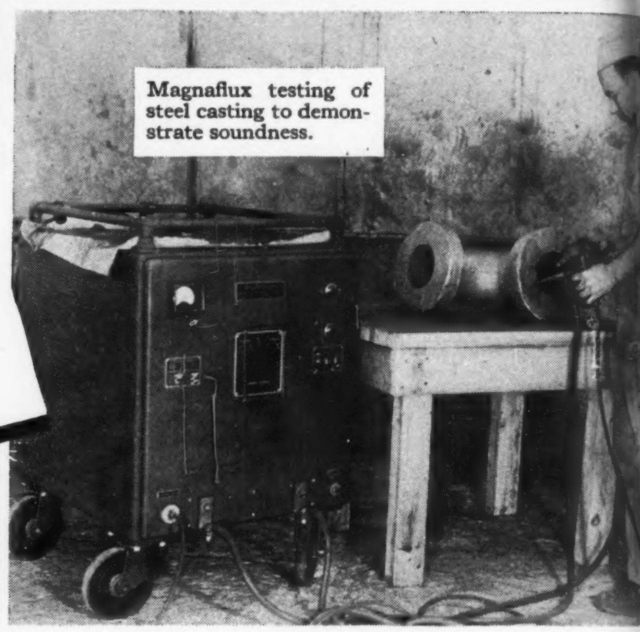


Testing cast steel crank-shaft with 1,000,000-volt X-ray machine.

Gamma-ray t
group of steel c
using radium c

STEEL CASTINGS

Twice-proved



Magnaflux testing of steel casting to demonstrate soundness.

It's a lot tougher for a steel casting to "get into uniform" than for a man to qualify for Army or Navy. The tests are more exacting—a greater degree of perfection is demanded.

Steel Castings have no difficulty in proving their soundness and fitness for duty—first by passing through rigid magnaflux, gamma ray or million-volt X-ray tests, and then by standing up in service, no matter how severe.

Your steel foundry can give you any property of steel, or any combination of properties, the end use makes desirable. And generally at a considerable saving in time, labor and cost, as compared with any other method of achieving results with steel.

Tell your steel foundryman what you need—for today's production *and* tomorrow's. Or consult Steel Founders' Society, 920 Midland Bldg., Cleveland, O. There will be no obligation involved in getting the facts.

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS

A-B Precision Type Limit Switches are available in a wide variety of enclosures and operating levers. A few are illustrated below. See Bulletin 801-802 for complete line.

Bakelite Enclosures

For 1001 applications

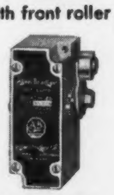
Roller lever operated

For panel mounting

Cast Iron

Water and dust-tight

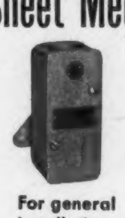
With front roller arm



With side roller arm

For cavity mounting

Sheet Metal



For general installations

PRECISION LIMIT SWITCHES

for Machine Tool Applications

This is the Allen-Bradley Bulletin 802 Precision Limit Switch! It is a tiny switch of husky design with big possibilities. In real life it measures only 1-15/16 inches long, 15/16 inch wide, and 27/32 inch deep.

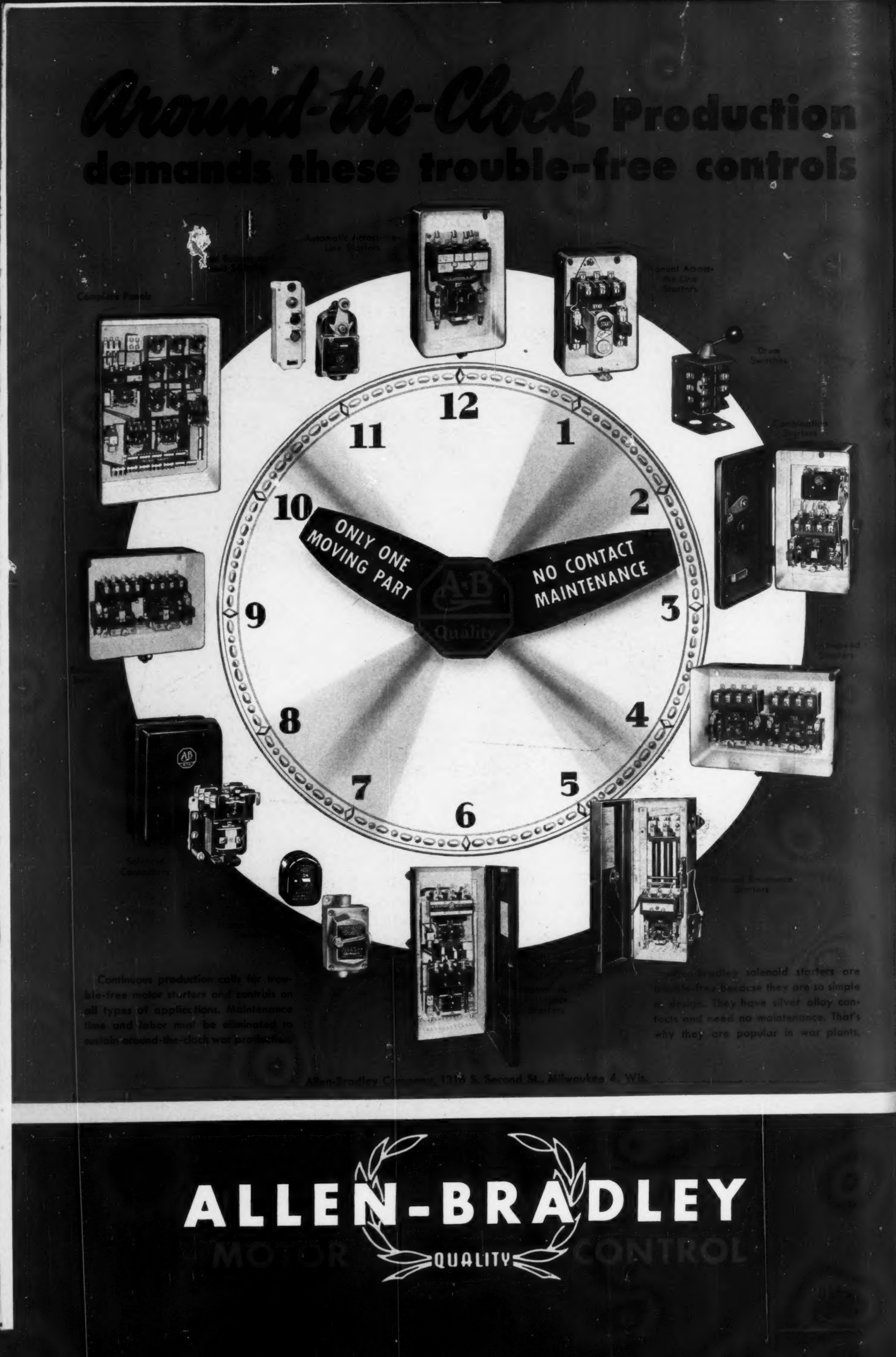
It requires a motion of only a few thousandths of an inch to snap it open or closed . . . and it is good for millions of switching operations without affecting its accuracy. Such a precision control has limitless possibilities. New applications are developing every day. And the A-B line provides a model for every use. Send for Bulletin 801-802. It's a handbook on limit switches for automatic machines.

A-B

ALLEN-BRADLEY

PRECISION TYPE LIMIT SWITCHES

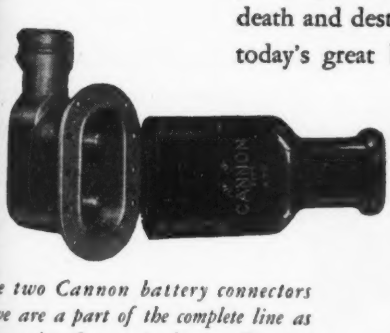
QUALITY


Around-the-Clock Production
demands these trouble-free controls
Automatic Across-the-Line Starters
Complete Panels
Drum Switches
Combination Starters
Solenoid Contactors
ONLY ONE MOVING PART
NO CONTACT MAINTENANCE
A-B Quality
Continuous production calls for trouble-free motor starters and controls on all types of applications. Maintenance time and labor must be eliminated to sustain around-the-clock war production.
Allen-Bradley solenoid starters are trouble-free because they are so simple in design. They have silver alloy contacts and need no maintenance. That's why they are popular in war plants.
Allen-Bradley Company, 1316 S. Second St., Milwaukee 4, Wis.
ALLEN-BRADLEY
MOTOR QUALITY CONTROL

In this war of many fronts, half-ton block busters are lifted by winch and motor into the yawning bellies of giant bombers . . . to spread death and destruction on our axis enemies. But today's great bombers, destruction bent, may seem puny in the light of tomorrow's aircraft, pursuing peacetime missions.

Great loads . . . entire boxcars in fact, may be the given load of aircraft in future peacetime years. And whether it's a carload of broccoli from California, a boxcar of bananas from the Tropics or pineapples from Hawaii . . . the energy expended in loading, lifting and also in flying will unquestionably be dependent in part on electrical circuits.

And wherever electrical circuits are involved, there you will more than likely find Cannon Connectors. For Cannon Connectors are used wherever electrical connections must be made quickly and with absolute certainty . . . in planes, tanks, communications, motion picture studios and hundreds of other civilian and military uses.



The two Cannon battery connectors above are a part of the complete line as shown in Cannon's latest Battery Connector Bulletin. Write today on your business letterhead for a copy.

BUY U. S. WAR BONDS AND STAMPS

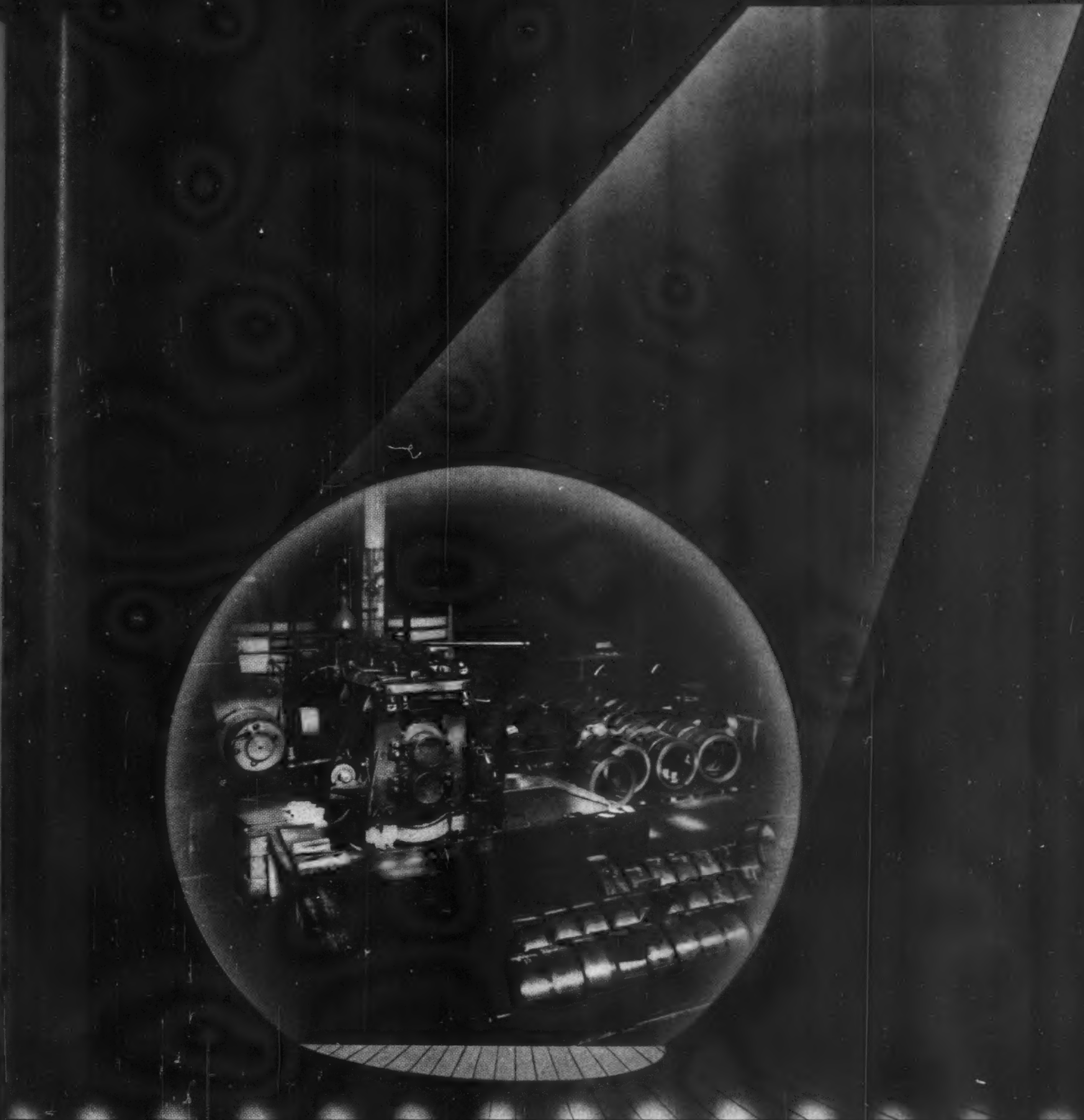
ARMY E NAVY

CANNON ELECTRIC

Cannon Electric Development Company, Los Angeles, California

Canadian Factory and Engineering Office: Cannon Electric Company, Limited, Toronto

REPRESENTATIVES IN PRINCIPAL CITIES — CONSULT YOUR LOCAL TELEPHONE BOOK

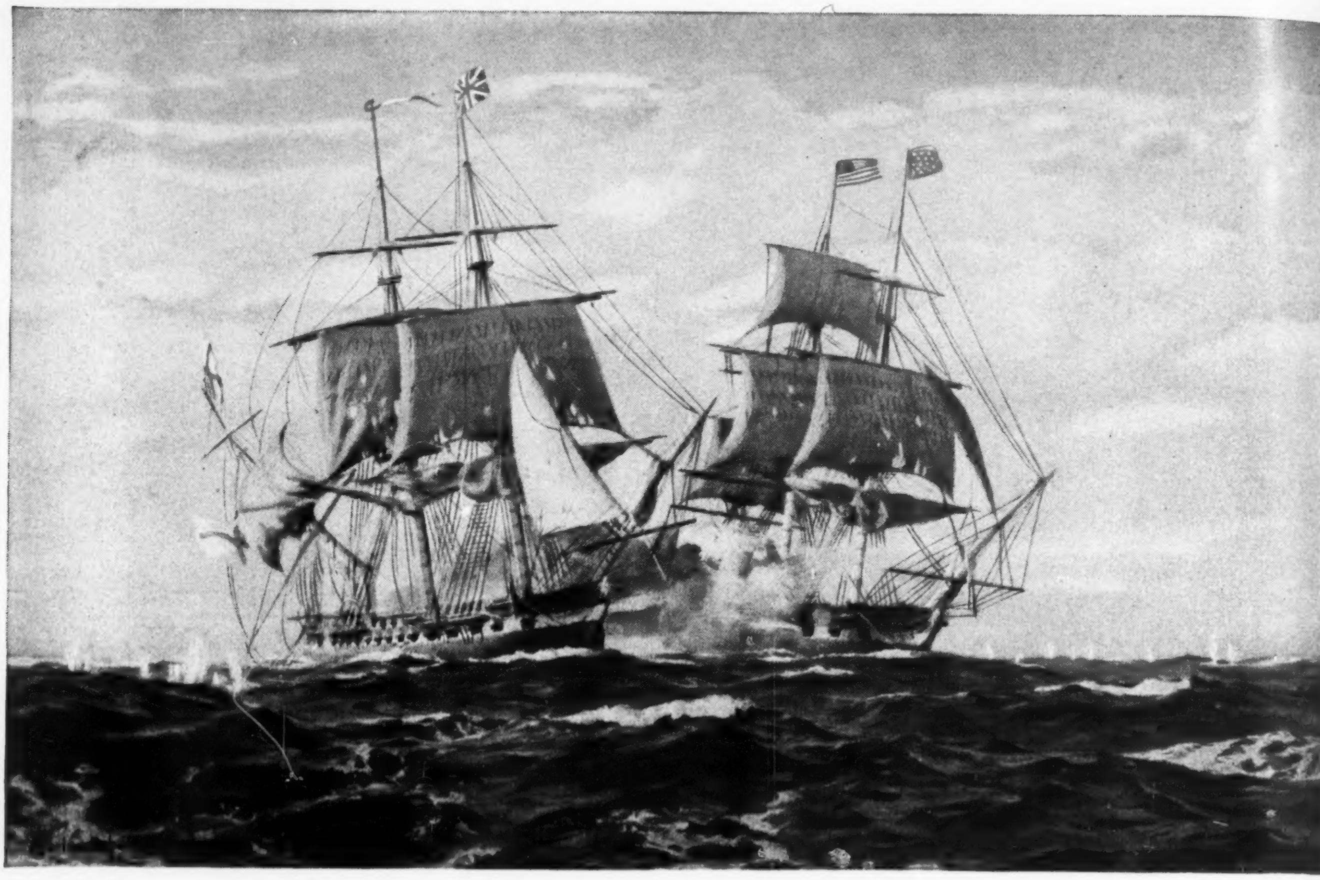


Strip Act— *very unpopular with the Axis!*

Spotlighted in the war production program is Superior's unique process for producing SuVeneer Clad Metal . . . bi-metallic, copper and steel *strip* . . . saving many thousand *tons* of vital copper each month in military service . . . a measurable factor in hastening Victory . . . immeasurable in *your* post war product fabrication!

SuVeneer ®Trademark Reg. U. S. Pat. Off. CLAD METAL

Superior Steel
CORPORATION
CARNEGIE · PENNSYLVANIA



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Today, as in 1812, our fighting forces "pour it into them"—from the work bench as well as the battle wagon, from the bond booth as well as the bomb bay. Men and women shape inevitable victory.

At PENFLEX, working side-by-side, they prod production so cargo and fighting ships can leave the ways sooner and keep sailing longer. Penflex Pneumatic Rivet Passers in the shipyards; Penflex Flexible Galvanized Steel Diesel Exhausts, Starting Air, Circulating Water and Oil Lines in the engine room; Penflex on war production machines.

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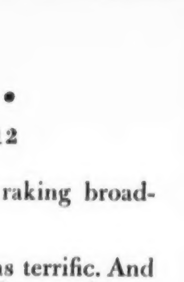
H.M.S. CYANE
and
H.M.S. LEVANT
February 20, 1815

Though Army and Navy requirements come first, PENFLEX may still be able to help you—What's your priority? Engineering Bulletins to help you solve your problems are still available. Write us.



PENNSYLVANIA FLEXIBLE METALLIC TUBING CO.

PENFLEX METAL HOSE

Established 1902 7250 POWERS LANE • PHILADELPHIA 42, PA.

HELPFUL LITERATURE

for Design Executives

1. Bearing Metal

National Bearing Metals Corp.—4-page illustrated bulletin entitled, "Silver Babbitt Helps Win the War," discusses bearing properties of this babbitt metal. Claimed features include retention of hardness at elevated temperatures, ease of bonding, resistance to corrosion, ease of handling and resistance to squeezing out at operating temperatures.

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Lincoln Engineering Co.—12-page illustrated bulletin No. 671 explains design operation and application of "Centro-matic," lubricating systems which automatically supply required amount of lubricant to all bearings in mechanical equipment. System may be power or manually operated.

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5. Metal Bellows

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American Felt Co.—Sample card contains representative specimens of "Aerofelt" S.A.E. felts which are coated with rubberized compounds, synthetic rubbers, resins, asphaltums and other materials. This coated felt is available in strips, washers, grommets and intricate parts cut to specification and serve as alternates for parts formerly made of rubber and other critical materials.

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14. Check Valves

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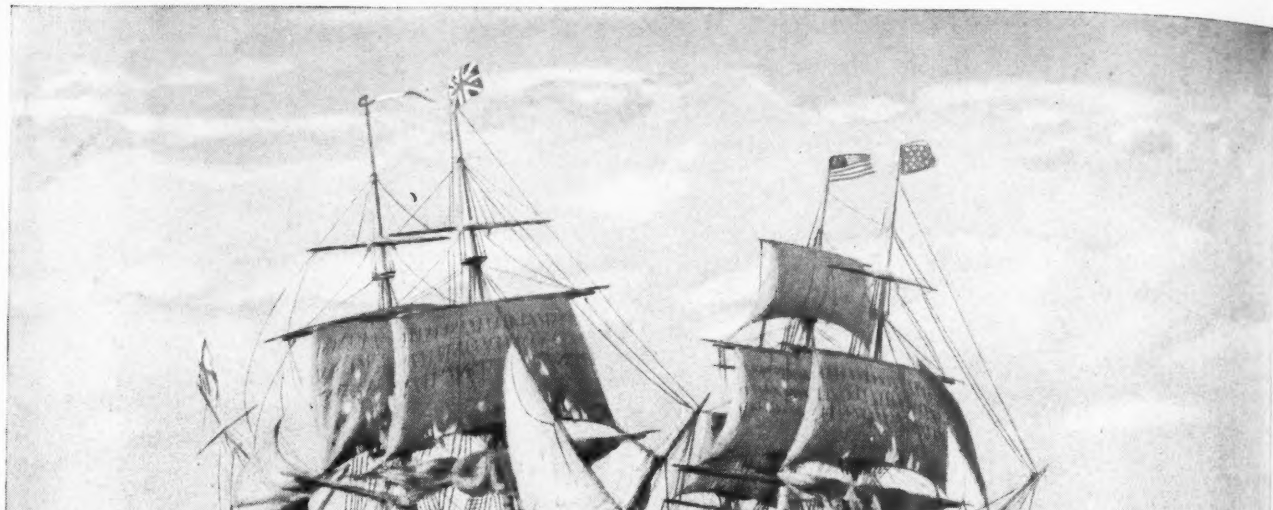

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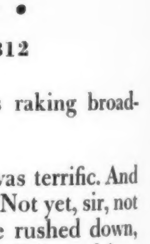

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20. Electronic Tubes

Electronic Enterprises, Inc.—11-page loose leaf specification booklet on "E-E" power and transmitting electronic tubes contains technical data on these units which are being manufactured for war purposes. Complete data are included on mercury vapor rectifier tubes, half-wave high-vacuum rectifier, power amplifier and transmitting triodes. Maximum ratings and operation data are tabulated.

21. Metal Blackening

Enthone Co.—8-page illustrated bulletin on "Ebonol" blackening processes for metals outlines procedure, characteristics of coatings and advantages of various types of materials for blackening copper and copper alloys, iron and steel, aluminum and aluminum alloys, and zinc and zinc alloys. Black finishes which are produced are claimed to be stable adherent hard oxides.

22. Marine Switch

Square D Co.—Illustrated bulletin No. 3100 is descriptive of single and double throw electrical switches for marine applications which are built to Government Specifications. Type K marine switches are described. These are splash-proof and meet Navy Specifications. They are available in two or three pole styles, rated from 30 to 100 amperes at 250 or 575 volts, fusible or not fusible.

23. Adjustable Work Lights

Reliable Devices Co.—4-page illustrated bulletin No. 102 is descriptive of universally adjustable "Work-Lite" units which are unaffected by machine vibration, remain in fixed position at any angle and have no screws or wing nuts which require adjustment. These lamps may be attached to machines, walls, benches or other equipment where close work requires maximum lighting.

24. Copying Machine

Remington Rand Inc., Photographic Records Div.—4-page illustrated bulletin No. DEX-80 is descriptive of two models of "Portagraph" reproduction outfits. These portable units will reproduce accurately anything which has been written, printed or drawn. Sizes of units are 9 by 15 and 20 by 24 inches. Also covered are larger machines.

25. Cowl Ring Link

Kinney Engineering Co.—2-page illustrated bulletin discusses design and application of "Kinney" aircraft engine cowl ring connector link which absorbs vibration and takes up engine expansion.

26. Aircraft Chains

Link-Belt Co., Aircraft Chain Div.—36-page illustrated looseleaf engineering data book No. 1825 contains complete information needed when designing chains and sprockets into aircraft applications. Both roller and silent chain types are described. Data given includes dimensions of chains and wheels, tensile strengths, weights per foot, end fastener details, chain elongation curves, how to calculate chain centers and lengths of chain required, metal hardness conversion table and related formulas.

27. Pressure Gages

Vinco Corp.—16-page illustrated bulletin entitled, "Millionths of an Inch for Sale," is descriptive of plain cylindrical, straight-side spline, thread ring, serration spline, involute spline and other precision gages and masters. Also shown are gear rolling fixtures, optical master inspection dividing head, cam comparators, master involute checker, spline and gear grinder, angle tangent to radius dresser and other precision machines.

28. Anti-Friction Bearings

Ahlberg Bearing Co.—32-page illustrated bulletin entitled, "Facts About Anti-Friction Bearings," discusses principles of anti-friction bearings and describes ball bearing types. Data are also included on tapered and straight roller bearings. Bearing numbers of standard manufacturers are tabulated in equivalent list. Pillow blocks, flange units, line shaft hanger bearings, take-up units and machine units are briefly described.

29. Gaskets

Goetze Gasket & Packing Co.—New series of technical bulletins covering design, manufacture and application of gaskets is available to engineers and others concerned with application of gaskets. Current bulletin explains laboratory and testing methods used in determining factors involved in gasket engineering. Succeeding issues will discuss study of each gasket type individually.

30. Plastic Tubing

Elmer E. Mills Corp.—6-page illustrated circular on "Mills-Plastic" tubing and fittings lists typical uses in many fields. Detailed data and physical properties of this flexible plastic tubing are included, with charts and tables of working pressures. Tubing and fittings are of S.A.E. type and are available in sizes ranging from ⅛ to ¾ inches. Plastic is chemically resistant and tubing is designed for high working pressures.

31. Electric Timers

Haydon Mfg. Co.—24-page illustrated catalog No. 112 on timing motors and devices contains technical data on full line of alternating and direct current timing motors. Such applications as radio keyers, time delay mechanisms for protection of vacuum tubes, multiple circuit repeat cycle timers and other uses are outlined. Technical data is included on full range of timing applications.

32. Radio Transformers

Standard Transformer Corp.—16-page illustrated bulletin No. 240 is descriptive of "Professional" series of transformers which are designed for audio, filament plate and other radio purposes. Included are tube, driver and modulation chart, numerical index and price list.

33. Laminated Plastic

Marathon Chemical Co.—4-page illustrated bulletin No. L-742 contains description, sizes and weights, physical, electrical and chemical properties, application data and machining information on "Lignolite" laminated lignin plastic.

34. Electric Brakes

Empire Electric Brake Co.—6-page illustrated folder on "Magdraulic" electric brakes discusses design, operation, advantages and typical applications of these units which are actuated by energized electro-magnet. These units are claimed to provide feather-touch operation, positive braking, low power consumption, high torque and ease of installation.

35. Tooling Service

Atlas Tool & Designing Co.—Illustrated bulletin outlines service offered by this company to aircraft industry. Facilities of company include staff of 300 engineers, designers and toolmakers which are available for consultation, design work; manufacture of tools, dies, jigs and special machinery, and supervision of production using this equipment.

36. Hose Clamps

Marman Products Co.—4-page illustrated bulletin on "Marman Clamps" shows features of these hose clamping devices which are available in dural, aluminum, cold-rolled, cadmium plated and stainless steels for hose diameters ranging from ¾ to 38 inches. Clamps hold with positive equalized tension around any convex surface.

37. Anti-Friction Bearings

Torrington Co.—8-page illustrated Volume [illegible] No. 2 of "The Bearing Engineer" contains articles on double direction roller thrust bearings, use of needle bearings and other data related to ball, roller and needle bearings. This regular publication is issued bimonthly and is available to all those concerned with bearings application, specification or purchase.

38. Time Controls

Automatic Temperature Control Co.—4-page illustrated condensed catalog B-2 contains brief descriptions and application information regarding dial, cam, combination, vernier-set and reset cycle timers. Information is included on auxiliary relays for controlling both high and low current circuits. Various systems using these timing devices are covered.

39. Bearing Metals

Magnolia Metal Co.—8-page illustrated bulletin describes various lead-base metals which are claimed to be long wearing on shock loads, heavy sustained pressures and general service. These babbitts are said to be excellent substitutes tor tin-base bearing metals. Suggestions are given for making and maintaining journal bearings. Included is table of recommendations for selecting correct type of bearing metal for 135 different types of machinery.

40. Electric Motors

Fairbanks, Morse & Co.—12-page illustrated bulletin No. 1160 describes protected polyphase squirrel-cage motors which are available in sizes ranging from ½ to 600 horsepower. Full specifications, dimensions, frame sizes and motor characteristics are tabulated for all models.

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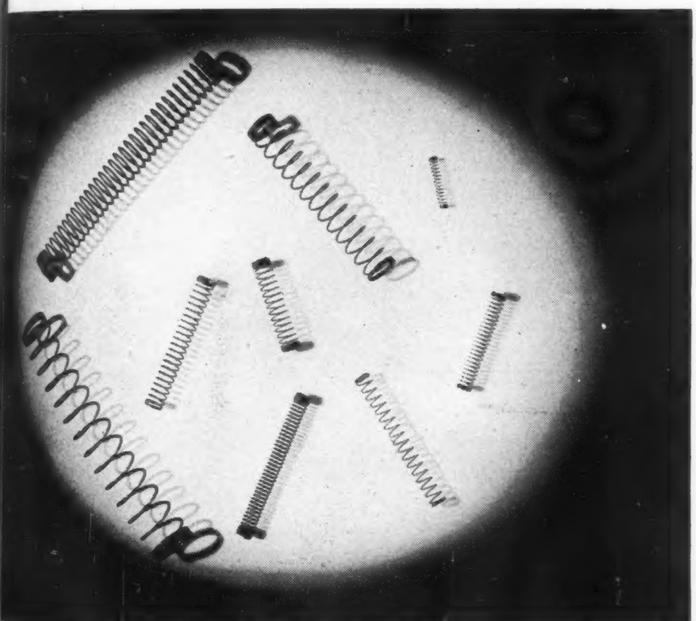
To the Seven Men in Eight who Never Need Anything but "Average" SPRINGS

As producers of over a million and a half beryllium copper coil and flat springs a week, we at Instrument Specialties are in an ideal spot to see how many "average" spring orders are filled before one "fancy" spring job comes through. We are also in the ideal spot to see how readily many springs which function under "average" conditions may be improved in their operating characteristics by "Micro-Processing" — an exclusive I-S process.



There is no premium on micro-processed beryllium copper brush springs which increase brush life 25% or more, because that is the only way we know how to make them. And, in the bargain, our production methods and material in stock assure quick delivery.

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Light weight design is possible without sacrifice of structural strength in any part that can be forged. Forgings can be used to reduce dead weight. Numerous instances may exist in your product, where improvements can be obtained through the use of dependable forgings. A check up by one of our forging engineers may reveal specific units wherein the IMPROVEMENT OF METALS BY FORGING, would improve your product to meet the new conditions.

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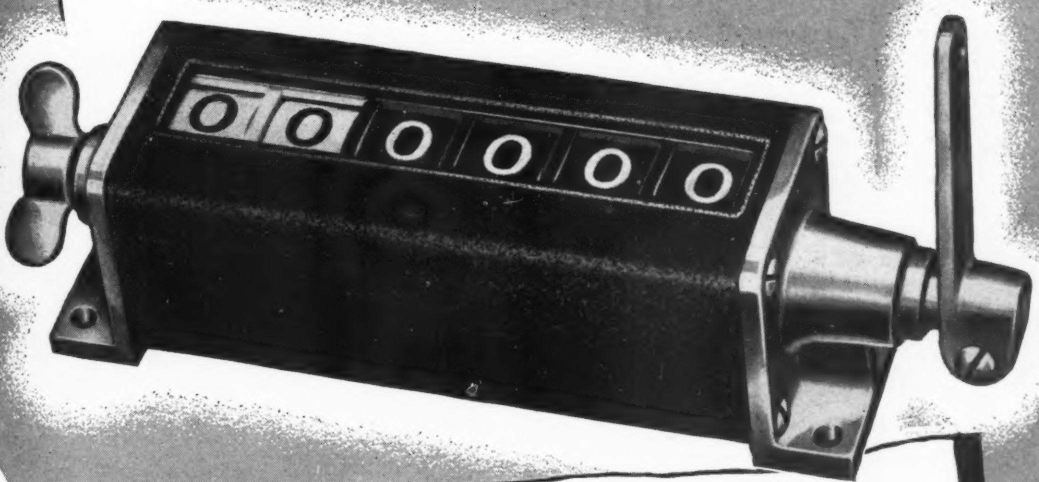
A built-in VEEDER-ROOT COUNTING DEVICE is a PRODUCTION "RANGE-FINDER"



. . for Users of your Machines

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In fact, many production men in war plants today know that no war-production machine is a complete machine *unless it can count*. They value highly this extra utility . . . which helps them prevent delays, errors, and shortages. And it's a simple matter for you to give it to them. For Veeder-Root Devices are inexpensive . . . compactly designed to fit into any design-requirements . . . and they are made in scores of different types, to count electrically or mechanically in any terms or units of performance. Let a Veeder-Root engineer show you exactly how Veeder-Root Devices can help your machines *to make their work count for more*, on your customers' production lines.

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WANTED: Mechanical or hydraulic design engineers by prominent Ohio client, manufacturing centrifugal pumps and other machinery. There are several openings with excellent post-war possibilities. One opening requires only machinery or machine tool design experience, another hydraulic experience as applied to machine tools and the third centrifugal pump experience in the design of mixed flow, axial flow and Francis impellers and cases. All applicants must conform to War Manpower rules. Perrin-Paus Co., 8 South Michigan Ave., Chicago.

WANTED: Machine designer—experienced on the design of special machinery and machine tools. This is an excellent opportunity for a first class man interested in a steady position in New England. Only men 35-55 with a record of successful achievements will be considered. In replying furnish complete information preliminary to a conveniently arranged interview. Address Box 218, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Development engineer. College graduate with experience in rubber mountings, vibration and sound dampeners for engineering development and technical sales work. Applicant should be qualified to take charge of design, construction and installation of experimental units. State age, experience and salary expected. (Midwest concern). Address Box 223, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: 1. Mechanical Engineers—experienced in design and development of products for quantity production. Must have knowledge of manufacturing practices. 2. Tool and Die Designers—small and medium size work. Draftsmen—experienced in product layout and/or detailing, also those inexperienced but trained. This increase in staff is required to take care of war work of high military urgency and for post-war requirements. If you are employed in essential war work to the full extent of your skill, do not apply. Write to: Personnel Office, Delco Radio Division, General Motors Corp., Kokomo, Indiana.

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AVAILABLE: Graduate mechanical engineer with 15 years experience selling manufacturers in Pennsylvania, New Jersey, New York and New England, wishes to represent one or two manufacturers of mechanical lines on commission basis. Address Box 215, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Machine designer experienced in the design of special machinery and machine tools. This is an excellent opportunity for a first class man interested in a steady position. Only a man 35-55 with a record of successful achievement will be considered. In replying furnish complete information preliminary to a conveniently arranged interview. Address F. J. Stokes Machine Company, Olney P. O., Philadelphia, Pa.


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WHITNEY CHAINS
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on everything I'm responsible for!"
Production men bank on Whitney Roller and Silent Chains to keep their equipment operating 24 hours a day . . . every day . . . and to pack every hour with top production, maintained by a full and even flow of power. For responsibility is built deep into every pin, link, and bushing of every Whitney Chain . . . starting with the metallurgical control of Whitney alloy-armored steels and continuing through every step of manufacture and assembly. On all your equipment, too, you can bank on Whitney Chains to stand up and not let you down. And you can bank on any Whitney engineering assistance you need. Get drive troubles off your mind once and for all . . . make Whitney Chains your Victory Drives.
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TO ADVERTISERS

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A Record that Points to Products of Peace

● The many uses for Acadia Synthetic Products to ease the heavy duty shocks and all weather service of war machines will have their counterparts in coming peacetime products. Used for packings, diaphragms, grommets, ring seals, chafing strips and many other protective devices . . . Acadia Synthetic Products will continue to be in demand by U. S. designers who are at last freed from the danger of imported rubber scarcities. "Made in the U. S. A. from domestic materials" means that Acadia Synthetics are making a vital contribution to the war effort and the peace to follow. Let Acadia engineers help you to solve any problem requiring the use of Synthetic Rubber.

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TURRET
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TOOLS . . . .
Designed and manufactured by Scully-Jones and Company for use in your Turret Lathes, Multi-Spindle Machines, Hand and Automatic Screw Machines ★ ★ ★ These standard tools will prove adaptable to a wide variety of work ★ ★ ★ *For Special Turret Tooling our Engineering Staff will gladly furnish designs and quotations.*
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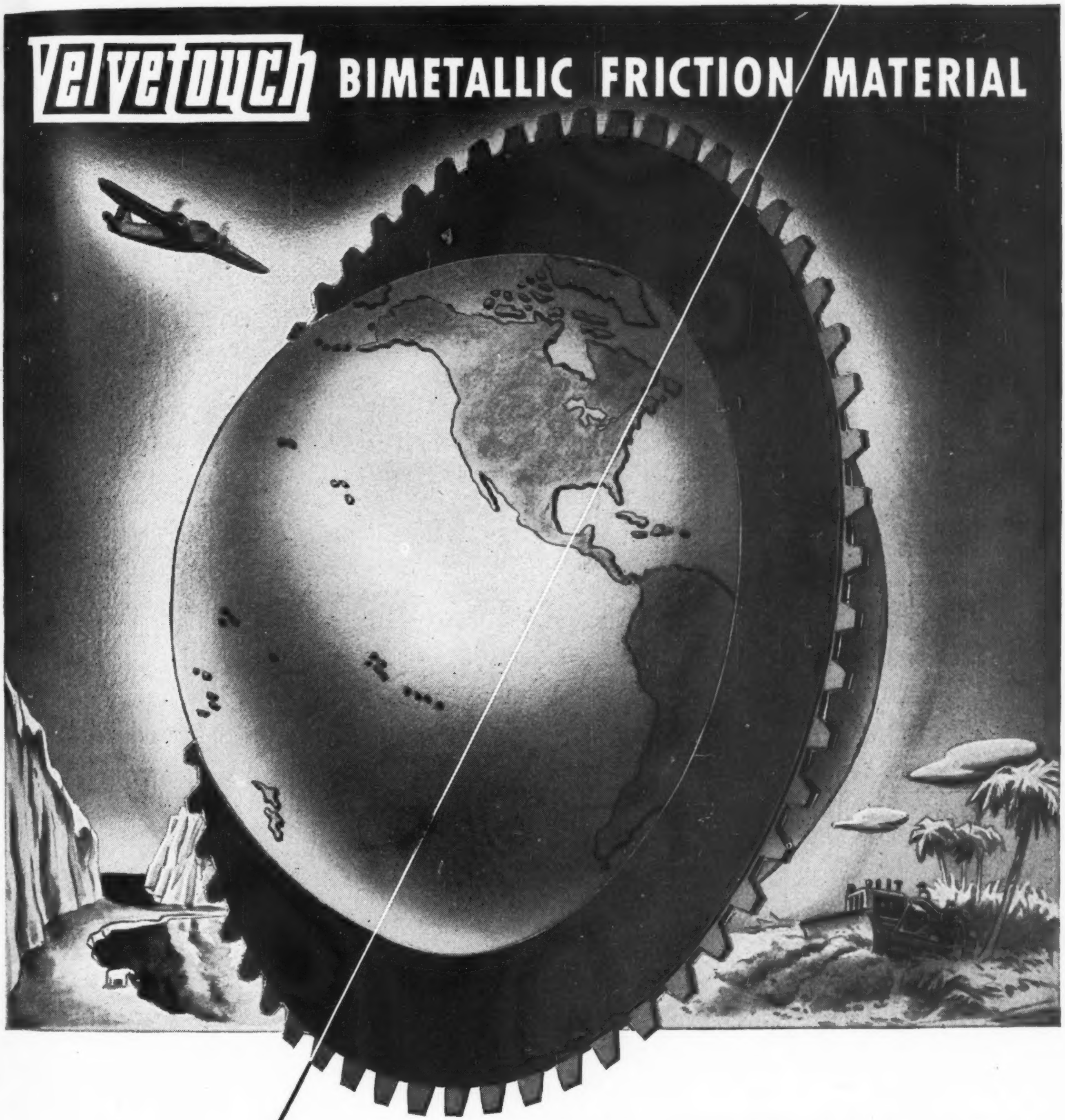
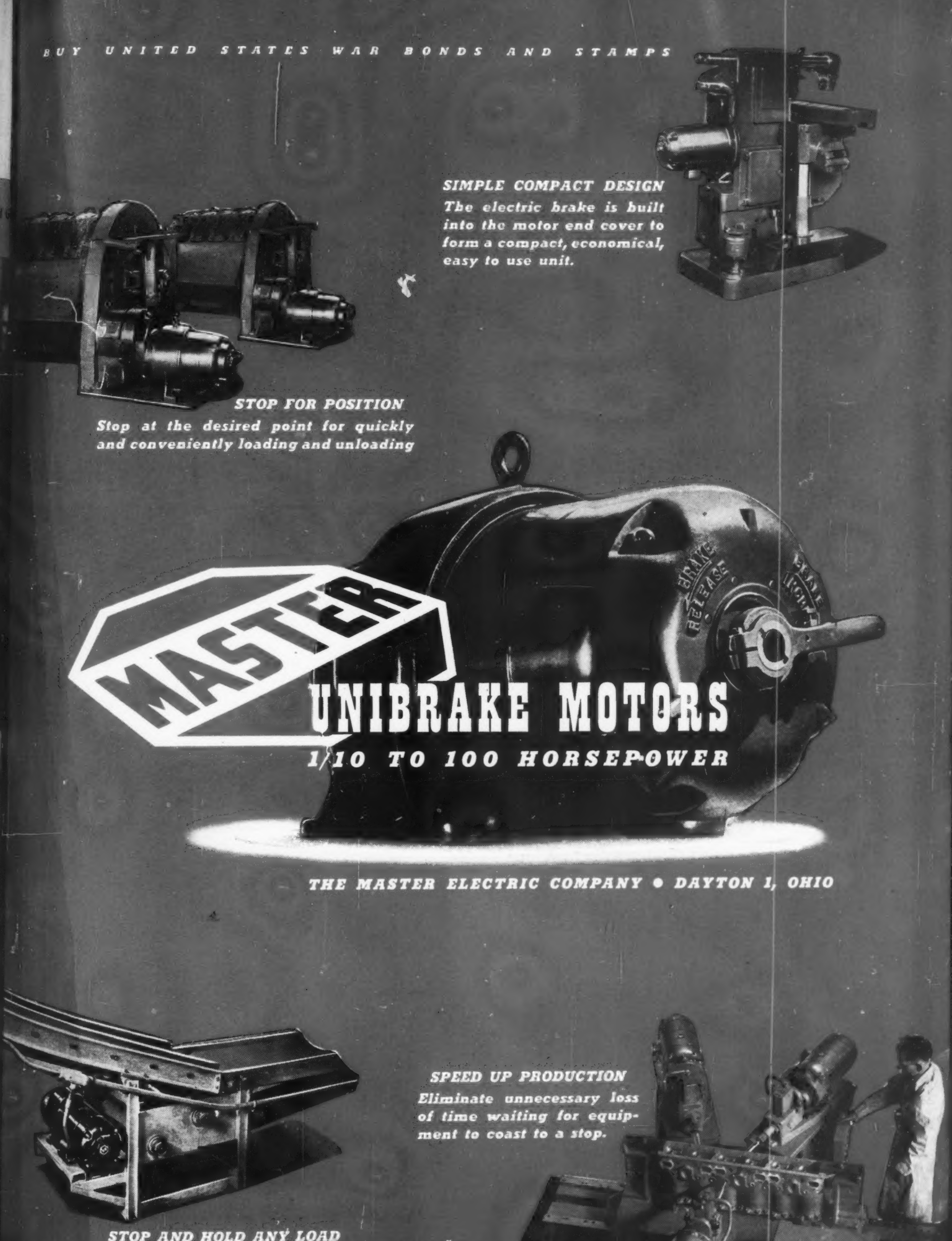

Velvetouch BIMETALLIC FRICTION MATERIAL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SIMPLE COMPACT DESIGN
The electric brake is built into the motor end cover to form a compact, economical, easy to use unit.
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Stop at the desired point for quickly and conveniently loading and unloading
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UNIBRAKE MOTORS
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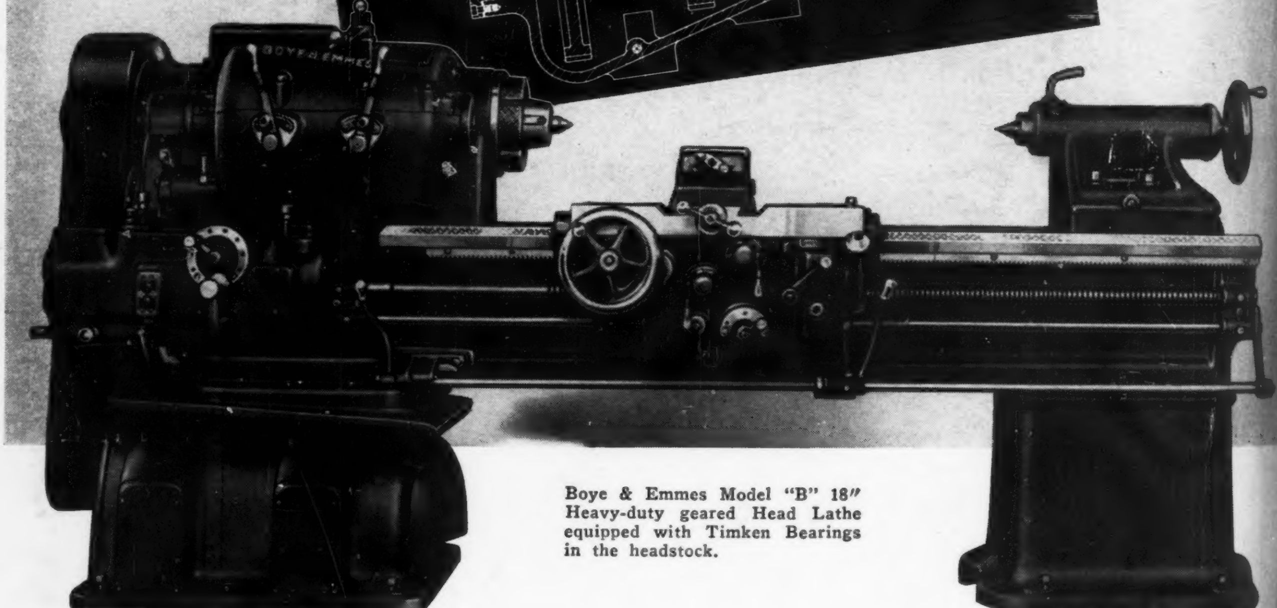
Eliminate unnecessary loss of time waiting for equipment to coast to a stop.
STOP AND HOLD ANY LOAD
Unibrake motors are very advantageous on hoists, elevators, inclined conveyors, etc....

The machines behind the machines
that are winning the WAR!

Application of Timken Bearings in the headstock of the Boye & Emmes lathe.



Boye & Emmes Model "B" 18" Heavy-duty geared Head Lathe equipped with Timken Bearings in the headstock.

One of the principal reasons why American industry was able to swing its entire weight into war production so quickly after Pearl Harbor was the tremendous number of modern standard machine tools — lathes, milling machines, drilling machines, boring machines, grinders, planers, gear hobbers, etc.—available.

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